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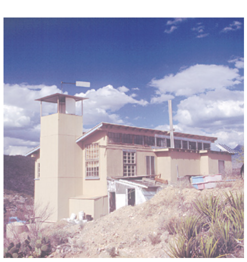
HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #41 June / July 1994

Features



GoPower

Things that Work!

Cover: After 100,000 years of burning things, we've finally found better energy sources. See page 6. Photo by Richard Perez

Fundamentals

Homebrew

Columns

Regulars

Access and Info

Access Data

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Tools

What's your tool of choice? Here at *Home Power*, one tool is the renewable energy system that allows us to live and work out in the country.

Tools (like kindergarten toys) are meant to be shared. Many folks share their knowledge with us — their experience setting up a solar electric, wind, or hydro system, for example, or building a battery box. We use another tool, our computer system, to produce *Home Power* and share these different technologies and uses of RE with folks around the world.

And folks around the globe use different tools. In eastern Africa, the KARADEA solar training center is teaching locals to install one module systems in homes and businesses. Electricity allows new tools — lights and radio — to extend the day and expand the world of these rural people. Two billion people — 70% of the developing world — have no electricity, but in eastern Africa solar electricity is rapidly developing — 30,000 systems in the last five years!

The Chinese have their own photovoltaic modules and controllers. The Solar Electric Light Fund used these tools and added their own: loans for people to purchase solar electric systems. Now, rural Chinese in MaGiacha can breathe easy and study late with fluorescent lights instead of burning kerosene lamps.

And from Chile, we hear of another tool of choice: solar cookers. In Villaseca, folks are building and selling solar cookers. They are selling solar baked bread. Their tool allowed them to eat a little better, make a little money, and improve their homes and soccer fields.

Energy is a tool available to us all. We can learn from each other how to use it wisely.

For the last 17 issues of *Home Power*, I have learned much about energy use and conservation, as well as living in the country. This knowledge is now my tool as I leave Home Power Central on Agate Flat to study architecture — another tool to incorporate renewable energy use and conservation. I may be leaving *Home Power* physically, but believe me, I'll be returning some of those borrowed tools!

Therese Peffer for the Home Power crew

People

Bill Battagin
Jay Campbell
Sam Coleman
Gary Cook
Jeff Dailey
Dave Doty
Louise Finger
Chris Greacen
Michael Hackleman
Mark Hankins
Kathleen Jarschke-Schultze
Kurt Janke
Stan Krute
Don Loweburg
Harry Martin
Therese Peffer
Karen Perez
Richard Perez
Shari Prange
Mick Sagrillo
Bob-O Schultze
Charles Van Meter
Michael Welch
John Wiles
Neville Williams

" Think about it…"

"Born Empty handed,
Die empty handed.
I witnessed life at its fullest,
empty handed."

Mutant Messenger, 1991
Mutant Message Downunder
(see page 92 for book review)

Energy Depot
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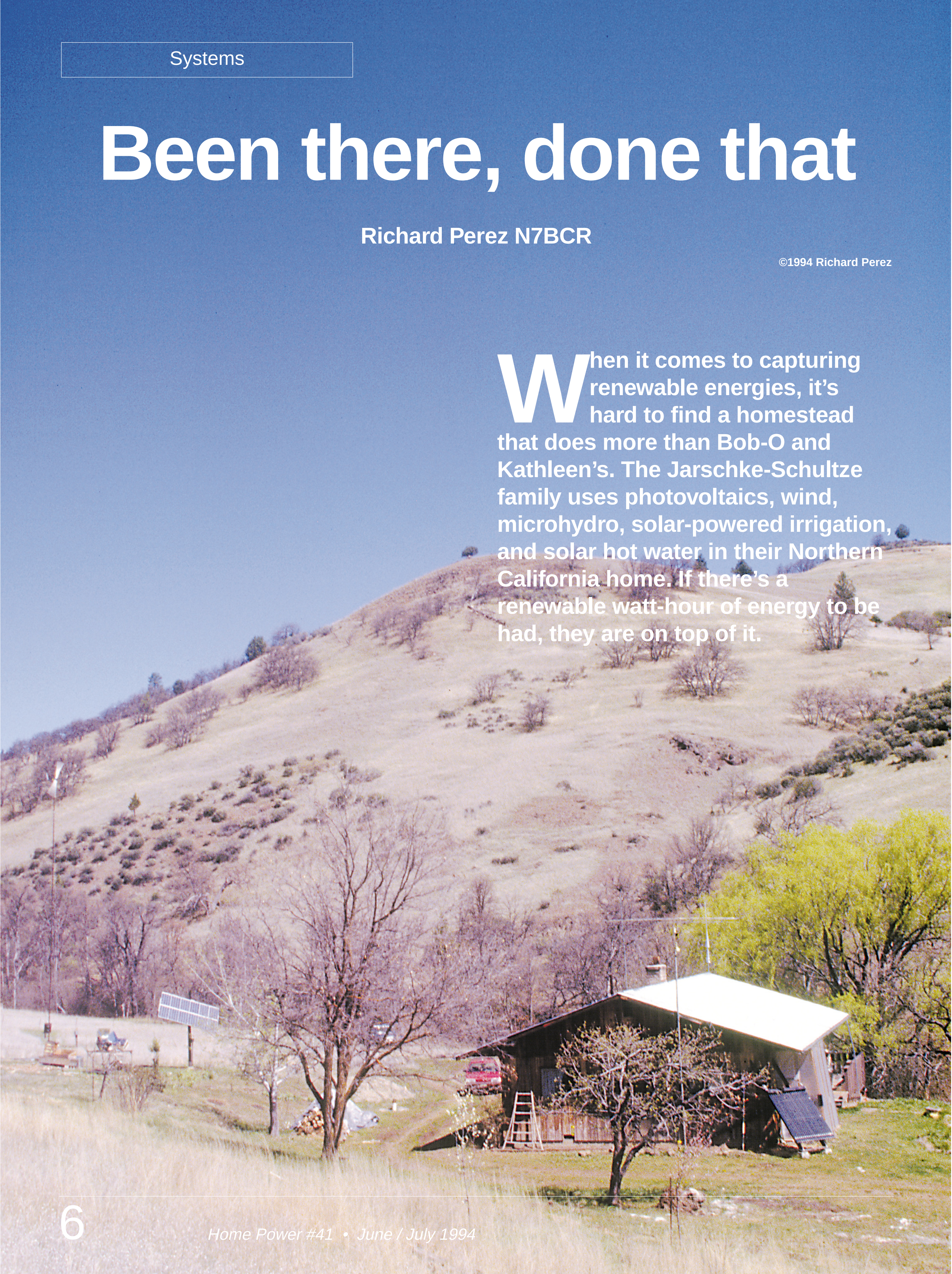
Systems

Been there, done that

Richard Perez N7BCR



When it comes to capturing renewable energies, it's hard to find a homestead that does more than Bob-O and Kathleen's. The Jarschke-Schultze family uses photovoltaics, wind, microhydro, solar-powered irrigation, and solar hot water in their Northern California home. If there's a renewable watt-hour of energy to be had, they are on top of it.

A personal note

This renewable energy system displays demented attention to detail. A system as complex as this one takes years to evolve. Very few instantly accomplish what you will see here. In order to understand this system's design, you must first meet the people who live with this system — especially Bob-O Schultze, the system's designer and installer.

Been there

I first met Bob-O and Kathleen in 1988. He and a group of readers visited Agate Flat about Issue #5. They were all living on renewable energy and had to check out this new magazine. Karen and I were amazed. They were the first readers to brave our eight mile long four-wheel driveway.

These hardy folks lived along the banks of the Salmon River in Siskiyou County, California. They were a collection of loggers, tree-planters, gold miners, back to the landers, and refugees from the cultural wars of the 1960s.

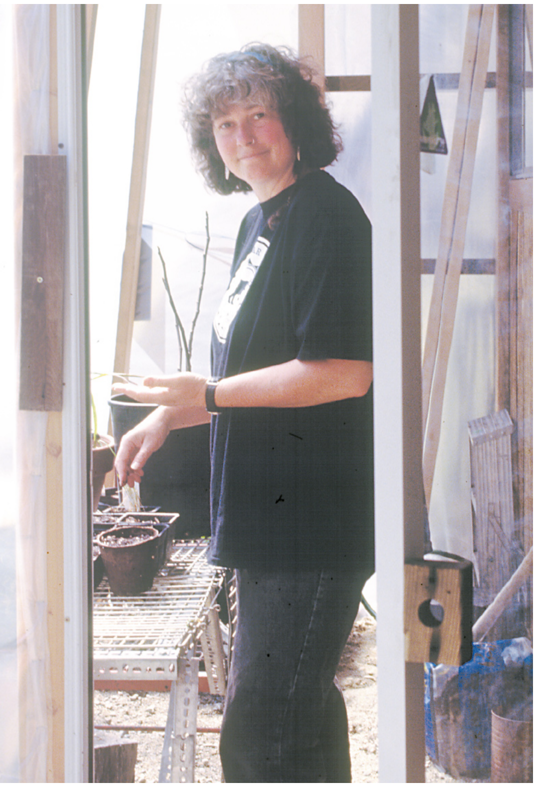
I became fast friends with Bob-O. He and I shared common interests in renewable energy, electronics, and radio. Bob-O, Kathleen, and Bob-O's son Allen were living beside the Salmon River on a mining claim aptly named "Starveout" due to the seasonal nature of the water run off needed to mine.

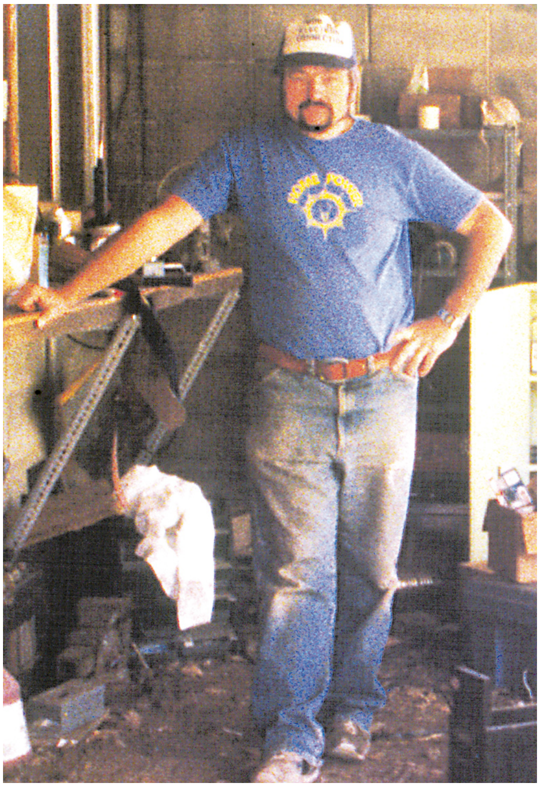
Done that

"Starveout" was powered by a small hydroelectric system that Bob-O installed in 1980. One of the reasons he came to visit us was to thank me for publishing the Mark VI Field Controller circuit (see *HP*#2) which he built to ride herd on his hydro alternator. In 1987, Bob-O and Carl Eichenhofer began manufacturing and selling small hydroelectric turbines called "Lil Otto". Bob-O was busy helping electrify the Salmon and Klamath River dwellers with renewable energy and installed over 20 systems along the rivers in five years. But most of the family's livelihood came from working the woods — brushing, tree planting, and logging.

In 1990, Bob-O had an accident — a tree he was felling kicked back and crushed his leg. After two weeks in the hospital, he was looking for a new job. With a leg full of metal, logging was out. Kathleen gave him the word, "You weren't fast enough to get out of the way last time, you're a lot slower now." Then, the U.S. Forest Service began cracking down on old mining claims along the Salmon. "Starveout", the Schultze's home, was on the hit list. Now Bob-O and Kathleen are serious folks. Rather than wait for the shoe to fall, they listened when Fate spoke. No job, no home. Well, it must be time to move!

And move they did. Bob-O took over Electron Connection, got his California Electrical Contractor's license, and began devoting full-time attention to renewable energy systems. Kathleen came to work with us at Home Power Magazine. They live six miles from Home Power Central and two miles from the end of the power lines. Bob-O uses his home as a test bed for new products and system design ideas. Over the years, I have watched their system grow into its present state.





Above: Kathleen in her greenhouse.

Below: Bob-O in his workshop.

Energy Requirements

Bob-O operates Electron Connection from his home. This means that his computer system is running much of the day to handle the routine business of designing and selling renewable energy systems. Kathleen also has an office in her home with her own computer system. Their renewable energy system supports two full-time business computer systems in addition to their family's domestic power use. The table here details their electric power use.

Renewable Energy Resources

The Schultzes are one of the fortunate few who live at a site that has solar, wind and hydro resources. Bob-O, Kathleen and Allen live next to Camp Creek about seven miles south of the summit of Soda Mountain. A narrow steep valley follows Camp Creek's watercourse and ends at the man-made Iron Gate Lake. From the summit of Soda Mtn to Iron Gate Lake, the land falls over four thousand feet in less than nine miles. The Camp Creek canyon is a natural wind tunnel driven by cooler air on the mountain and the large lake acting as a thermal flywheel. Water flow in Camp Creek is high during all but the depth of summer.

The most interesting aspect of this site's resource survey is that no one of these sources is reliable enough to provide continuous power. During the winter, the nearby lake provides healthy doses of dense fog and low clouds. During midsummer, the creek slows to a trickle. The wind is strong whenever a weather front passes through or whenever the weather is driving Camp Creek's wind tunnel. It's a case of using what Mother Nature offers when she offers it.

Bob-O didn't start out by capturing all these renewable resources at once. First he developed the photovoltaic system, then the hydroelectric turbine, and finally the wind electric generator. It took over four years to build what you see here.

Bob-O and Kathleen's Appliances

Appliance Energy Consumption

No.	*Inverter Powered Appliance*	*Run Watts*	*Hours /Day*	*Days /Wk*	*W-hrs /day*	*%*
1	Bob-O's Sony 1730 Monitor	140	9.0	5	900.0	13.8%
1	Katheen's NEC4FG Monitor	118	8.0	5	674.3	10.4%
1	Bob-O's Mac II Computer	99	9.0	5	636.4	9.8%
1	Kathleen's Mac II	101	8.0	5	577.1	8.9%
2	Answering Machines	10	24.0	7	480.0	7.4%
1	Television Set, Signal Amp	100	4.0	6	342.9	5.3%
3	Fluorescent Lights (House)	22	4.0	7	264.0	4.1%
1	Fax Machine	10	24.0	7	240.0	3.7%
2	Kathleen's Desk Lights	15	8.0	5	171.4	2.6%
1	Washing Machine	350	1.5	1	75.0	1.2%
2	DeskWriter Printer (idle)	6	8.0	5	68.6	1.1%
1	Shoplight	75	1.0	6	64.3	1.0%
2	Incandescent Lights	15	2.0	7	60.0	0.9%
1	Kirby Vacuum Cleaner	400	1.0	1	57.1	0.9%
1	Video Cassette Recorder	16	4.0	6	54.9	0.8%
1	Power Tool	750	0.2	2	42.9	0.7%
1	Main Stereo System	65	1.0	4	37.1	0.6%
1	Microwave Oven	800	0.1	3	34.3	0.5%
1	Shoplight	40	0.3	7	12.0	0.2%
2	DeskWriter (printing)	15	0.5	5	10.7	0.2%
1	Allen's Stereo	5	2.0	7	10.0	0.2%
1	B & K's Radio	5	2.0	5	7.1	0.1%
1	Makita Battery Charger	15	1.0	3	6.4	0.1%
1	Food Processor	380	0.1	2	5.4	0.1%
1	Blender	350	0.1	2	5.0	0.1%
1	KitchenAid Mixer	325	0.1	1	4.6	0.1%
1	Modem Supra V.32bis	14	1.0	2	4.0	0.1%
1	Scanner HP IIp (idle)	8	1.0	2	2.3	0.0%
				Total	4848	Whr/d

Appliance Energy Consumption

No.	*12 VDC Powered Appliance*	*Run Watts*	*Hours /Day*	*W-hrs /day*	*%*
1	Sun Frost RF-16 Frig/Freezer	60	10.0	600.0	9.2%
1	Inverter Standby	16	24.0	384.0	5.9%
1	2 Meter Radio RX	6	24.0	144.0	2.2%
1	2 Meter Radio TX	45	0.5	22.5	0.3%
1	2 Meter Radio Amplifier	200	0.1	20.0	0.3%
1	HF Radio	100	0.5	4.0	0.1%
1	Metering - CE+, Equus	0.1	24.0	2.4	0.0%
1	Soldering Iron	20	0.1	2.0	0.0%
			Total	1179	Whr/d

Energy Sources

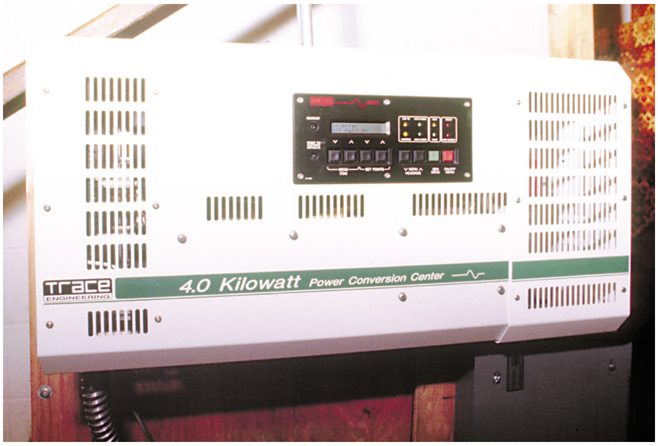
Above Left: Twelve Kyocera photovoltaic modules atop a two-axis Wattsun tracker generates over 4 kWh daily.
Above Right: A Whisper 1000 wind generator provides about 2 kWh on windy days.
Below Left: An Energy Systems & Design Hydro produces about 1.2 kWh per day.
Below Center: A Thermomax solar thermal collector provides hot water for the household.
Below Right: Two PV modules on a Zomeworks tracker supply water pumping power for Kathleen's gardens.

System Design
Bob-O was far sighted when he began designing his system. As the system grew to accept all three renewable energy inputs, only one major change required back-tracking — the conversion of the system's battery voltage from 12 to 24 Volts DC. This conversion was complex enough that Bob-O has written an article, on page 16, about the process.

The equipment used in Bob-O's system reads like a list of "Things that Work!" product tests. He wants the best and most cost-effective equipment in his customer's systems as well as his own. He refuses to sell a product that he "hasn't tried to break." And being a dealer means that he is exposed to all types of hardware applied in many different systems. Installing dealers, like the ones near you, quickly find out what works and what doesn't.

PV Electric System
The photovoltaic array consists of twelve Kyocera 51 Watt PV modules mounted on a Wattsun two-axis, active tracker. This array produces 18 Amperes of current at 30 VDC. With the added assist of the Wattsun tracker, the array produces about 4,000 Watt-hours of power on an average sunny day. One hundred and fifty feet (round trip wire length) of 1/0 AWG copper cable feeds the array's power to the house. See *HP*#25, page 56 for a "Things that Work!" review of the Wattsun tracker.

Energy Processing



Left: The new Trace 4,000 Watt sine wave inverter converts 24 VDC power into 120 vac housepower. Center: Eight Trojan L-16 batteries store the energy produced by the photovoltaics, wind generator, and microhydro. Surrounding the batteries are the various safety fuses, circuit breakers, disconnects, and the systems' regulators. Right: The inside portion of the solar hot water system — Rheem solar tank, Myson on-demand heater, pump, and valves.

Hydroelectric System

Bob-O uses an Energy Systems & Design turgo-type hydroelectric turbine. Even though Bob-O manufactures the Lil Otto turbine, he uses the ES&D model because it is more suited to his hydro site. A 3 to 2.5 inch diameter, 800 foot long pipe snakes its way up Camp Creek. The 27 feet of head created by this pipe supplies the turbine with 9.25 psi of working pressure and a flow of 35 gallons per minute. The hydro turbine produces 2 Amperes at 26 VDC or about 50 Watts of power. While this may not sound like much power, remember that the hydro is producing 24 hours a day. During a day's time, this hydro produces over 1,200 Watt-hours of energy. The hydro's electricity is delivered, unregulated, to the battery via 180 feet (round trip) of 6 AWG cable.

Wind Electric System

This spring Bob-O added a Whisper 1000 wind generator to the system. This wind genny sits atop a 63 foot high tower made from 2.5 inch diameter, Schedule 40, steel pipe. The guyed tower is located in a field about 200 feet northeast of the house. This generator produces over 30 Amperes at 28 Volts in 20 mph winds. Bob-O figures that the wind generator has been producing an average of 2000 Watt-hours of energy per day when the wind blows. Power is transmitted from the wind generator to the house by 380 feet (round trip) of 1/0 AWG cable.

Engine/generator

Bob-O comes from the group of RE users that would rather eat a bug than start the generator. Nevertheless, Bob-O had to fall back on his 3.5 kW Miller Roughneck generator/welder several times last winter (before the Whisper 1000 was up and running). He hopes the addition of the wind generator will permanently retire the Miller from generator service.

Batteries

This system uses eight Trojan L-16 lead-acid batteries to store energy. Each L-16 battery is rated at 350 Ampere-hours at 6 Volts DC. The battery is configured at 700 Ampere-hours at 24 VDC. Each cell in the battery is fitted with a Hydrocap® which recombines gaseous hydrogen and oxygen into pure water. These Hydrocaps not only keep the system safer by nearly eliminating the potentially explosive hydrogen gas, but reduce cell watering and battery top cleaning. The battery is located in the home's basement along with the inverter and power processing gear. The battery interconnect cables are made from 00 AWG copper cable with soldered ring terminal ends. All the batteries are sitting in Rubbermaid™ plastic tubs just in case there is any spillage of electrolyte.

Inverters

One of the major reasons that Bob-O converted the system from 12 to 24 VDC was to accommodate the new Trace 4,000 watt sine wave inverter. The inverter converts the low voltage power stored into the battery into 120 vac, 60 Hz sine wave power like the utility rents out. This new Trace inverter has been performing faultlessly since installed four months ago. Over the years, Bob-O has used just about every inverter available, and he thinks the new Trace is a definite "keeper". The inverter's output is wired directly into the home's mains panel where it is distributed to all the

Energy Use

Left: Bob-O at work on the phone. His office contains an extensive Macintosh system, FAX, copier, and answering machine — all powered by renewable energy. Center: Kathleen, a solar cooking expert, prepares dinner in one of her many solar ovens. Above Right: The living room contains the usual audio/video gear found in most homes. Below Right: This back country kitchen comes equipped with electric RE powered appliances.

home's branch circuits. Since the inverter produces sine wave power, all of the appliances in the house perform just like they were plugged into the utility.

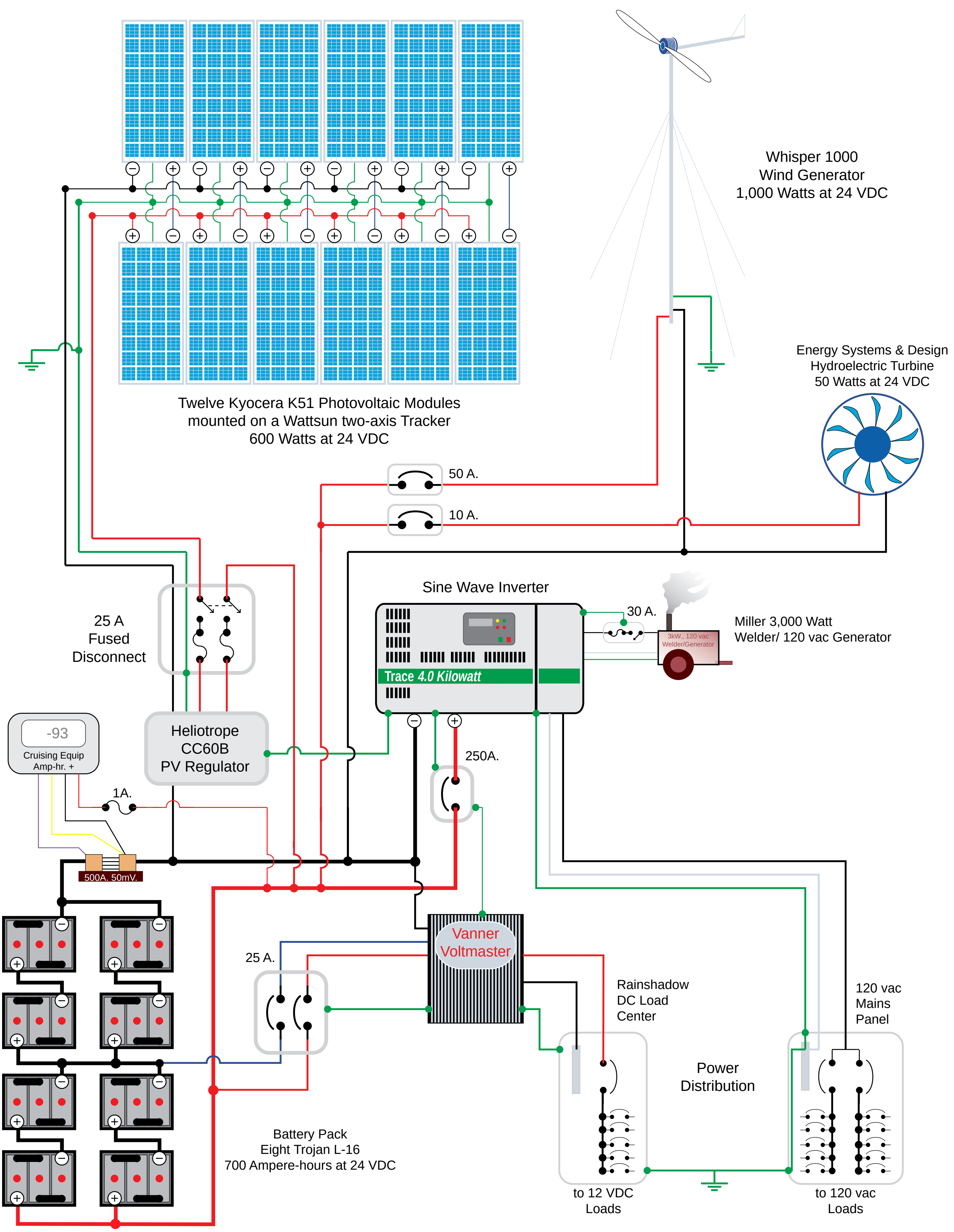
Regulators
Bob-O uses a Heliotrope CC-60B PV controller (see *HP*#8, page 31) set to regulate at 31 VDC. This is a little high, but the business uses so much power that Bob-O feels he'll take an equalizing charge whenever he can get it. The hydroelectric turbine produces less than 100 Watts and is not regulated. At this point in time, the Whisper wind generator is also not regulated. This has led to several inverter shutoffs from battery overvoltage. Bob-O's next project is getting the load diversion feature of the new Trace inverter to dump his excess power into heating water in the 80 gallon DHW tank. Once this is accomplished, the Whisper will be effectively controlled and all the system's surplus power will be diverted into making hot water.

Converters
When the system changed from a 12 Volt battery to a 24 Volt battery, Bob-O was faced with a decade's worth of 12 VDC appliances. Most were replaced by 120 vac models, but several stubbornly remained 12 Volt. In order to power this 12 Volt gear (like a Sun Frost RF-16 refrigerator/freezer and a whole rack of 12 Volt ham radio gear), Bob-O uses a Vanner Voltmaster. From a system design standpoint, the Vanner Voltmaster is a switching power supply that can efficiently convert power stored in a 24 VDC battery into 12 VDC for appliances. More technical details on this 12 to 24 conversion in the article that follows this one. See *HP*#33, pg. 84 for a review of the Voltmaster.

Instruments
Bob-O is an electronics nerd and his home is festooned with instruments of all types. Only two are in daily use to assess the system's performance — a Cruising Amp-hr+ meter, and a home-made expanded scale battery voltmeter. The Cruising Amp-hr+ is a battery Ampere-hour meter that functions like a gas gauge for batteries. In addition to calculating Ampere-hours in and out of the battery, the meter also measures battery current and battery voltage. See *HP*#26, page 59 for a review of this Cruising meter. The analog expanded scale battery voltmeter is a very simple homebrew project. See *HP*#35, page 92 for a schematic of this analog battery voltmeter.

Water Systems
The main water source is a spring located about 200 feet in elevation above the house. This spring provides gravity flow water for the house, but hasn't sufficient flow to supply Kathleen's many gardens. Bob-O uses a PV array direct water pumping system to supply over 1,500 gallons daily to the gardens. This system uses two Kyocera K51 PV modules powering a 24 VDC Flowlight Slow Pump. The PVs are mounted on a one-axis Zomeworks tracker and their power is processed by a Sun Selector LCB before being sent to the pump. This system is simple, effective and uses no battery. The water is pumped from Camp Creek into two 1350 gallon water tanks located about 40 feet in elevation above the gardens.

Bob-O uses a rack of twenty Thermomax evacuated tube, heat pipe, solar collectors to heat water for the house. This system has been operating for over two



Whisper 1000
Wind Generator
1,000 Watts at 24 VDC
Energy Systems & Design
Hydroelectric Turbine
50 Watts at 24 VDC
Twelve Kyocera K51 Photovoltaic Modules
mounted on a Wattsun two-axis Tracker
600 Watts at 24 VDC
50 A.
10 A.
Sine Wave Inverter
Trace 4.0 Kilowatt
30 A.
Miller 3,000 Watt
Welder/ 120 vac Generator
3kW., 120 vac
Welder/Generator
25 A
Fused
Disconnect
-93
Cruising Equip
Amp-hr. +
Heliotrope
CC60B
PV Regulator
1A.
250A.
500A. 50mV.
Vanner
Voltmaster
25 A.
Rainshadow
DC Load
Center
120 vac
Mains
Panel
Power
Distribution
Battery Pack
Eight Trojan L-16
700 Ampere-hours at 24 VDC
to 12 VDC
Loads
to 120 vac
Loads

Bob-O & Kathleen's System Cost

Photovoltaic System

12	Kyocera K51 PV Modules	$4,200
1	Wattsun 12 PV Dual Axis Tracker	$1,575
1	Heliotrope CC-60B Charge Controller	$295
1	C& H 60ADC Fused Safety Switch	$215
1	5"x10' Steel Pipe, Cement, Gravel, etc.	$150
150	feet of 1/0 AWG THHN Main Feeder Wire	$137
1	1 1/4" PVC Conduit, NEMA3J Box	$70
84	feet10 AWG USE PV Interconnect Wire	$27
1	Crimp wire terminals, Split bolts, tape, etc	$25
1	8' Copper Ground Rod, Clamp, Wire	$15
	System Sub Total	$6,708

Hydroelectric System

1	ES&D FT1 Hydro w/24V Low Head Stator	$830
600	feet of 2 1/2" PVC 160 Pipe	$420
200	feet of 3" PVC 160 Pipe	$244
1	Valves, Fittings, etc.	$60
90	feet of 6 AWG Triplex Wire	$45
1	SquareD QOCB Box w/DC Circuit Breaker	$42
	System Sub Total	$1,641

Wind Generator System

1	Whisper 1000 Wind Generator	$1,500
380	feet of Wire 1/0 THHN	$346
8	2 1/2" Flanges	$208
105	feet of 2 1/2" Sch 40 Steel Pipe	$160
700	feet of 1/4" Aircraft Cable	$158
1	1 1/4" PVC Conduit, NEMA3 JBox	$135
1	Sand & Gravel	$130
8	5/8" x 12" Turnbuckles (Surplus)	$96
1	Misc.Steel	$50
1	Misc.Wire, Terminals, etc.	$50
1	Cement	$42
1	SquareD QOCB Box w/DC Circuit Breaker	$42
48	1/4" Cable Clamps	$29
12	5/8" Bolt w/ Nylock Nut	$11
20	1/4" Thimbles	$11
2	3/4" x 6" Bolt w/ Nylock nut	$7
6	5/16 x 5" Bolt w/ Nylock Nut	$2
	System Sub Total	$2,976

Batteries

8	Trojan L-16 Lead Acid Batteries	$1,440
24	Hydrocaps™	$180
11	2/0 AWG,13.5 in. Battery Interconnects	$107
	System Sub Total	$1,727

Inverter

1	Trace SW4024 w/ Conduit Box	$3,045
1	Heinemann 250A Breaker w/ Enclosure	$245
2	Trace BC-5 4/0 Inverter Cables	$150
1	2" PVC Conduit, Fittings, etc	$12
	System Sub Total	$3,452

DC Load Center, Metering, etc.

1	Cruising Equipment Amp Hour+™	$325
1	20 Amp Vanner Voltmaster	$304
1	Rainshadow DC Load Center w/4 CBs	$215
1	SquareD QOCB Box w/DC CBC	$52
	System Sub Total	$896

Solar Irrigation System

2	Kyocera K-51 PV Modules	$700
1	Flowlight® Slowpump	$488
1	Zomeworks 2 Panel TrackRack™	$385
1	Sun Selector LCB model 3MT	$80
	Wire, Fused Disconnect, etc	$75
	System Sub Total	$1,728

Solar Hot Water System

1	Thermomax SOL 20S Thermal Collector	$1,723
1	Myson CF-325-2 Demand Heater	$610
1	Rheem SolarAide 80 gal. tank	$525
1	Heliotrope Delta T Thermostat/Control	$140
1	Laing Circulation Pump	$125
1	Amtrol Expansion Tank	$50
1	Relief Valve- Watts 174A	$44
	Valves, Vents, and Sensors	$120
	System Sub Total	$3,337

Solar Hot Water System Total Cost	$3,337
RE Electric System Total Cost	$19,128
Grand Total	$22,465

years and has survived numerous hard freezes and inch sized hail stones. These evacuated tubes have the insulation value of a vacuum bottle. Inside each two and a half inch diameter glass tube there is a finned heat pipe partially filled with an alcohol/water mixture. Sunshine causes this mixture to boil and heat is transmitted to a glycol mixture which in turn transfers the heat to the home's 80 gallon Rheem SolarAid hot water tank. This DHW system is rather complex with two stages of heat exchange and a single Laing pump (driven by 0.25 Amperes at 12 VDC). The reasons to undergo this degree of complexity are absolute freeze proofing and the incredible cold/cloudy weather performance of the Thermomax collectors. On sunny winter days when the ambient temperature is well below freezing and the wind is blowing, the Thermomax still delivers 180°F to the hot water tank. Bob-O also has a Myson on demand, propane-fired water heater on line. This Myson has the happy ability to moderate its heat output in relation to the incoming

Above: from left to right, Kathleen Jarschke-Schultze, Amelia Airedale, Allen Schultze, and Bob-O Schultze.

water's temperature. If the weather has been sunny and the solar hot water heater has been producing, then the water passes straight through the Myson without any additional heating. Using the on demand heater as a last resort ensures that the house will always have plenty of hot water regardless of the weather or the amount of hot water needed. This hot water system supports two bathrooms, a kitchen sink, and a washing machine. Between the months of May and October the pilot light on the Myson is shut off and the hot water needs are met by the Thermomax alone. Kathleen has a sign above the sink for visitors that reads, "Caution - Solar Heated Water - HOT!"

System Performance

Well, there is never a power outage at Bob-O and Kathleen's place. The photovoltaic array produces about 4,000 Watt-hours of power daily. The wind generator is a new comer to the system and we don't yet have years of data on its performance. If the wind is blowing, then Bob-O reports that the Whisper makes about 2,000 Watt-hours of energy daily. The small hydroelectric turbine produces about 1,200 Watt-hours of energy daily. Bob-O figures that he puts about 25 hours of operating time on the Miller engine/generator yearly. This system is about two-thirds powered by photovoltaics, with the remaining one-third divided between wind and microhydro.

The battery in Bob-O's system contains enough energy to power their homestead for about three days with no RE power input whatsoever. And since every day contains at least some renewable energy, the battery is virtually never fully discharged.

System Cost

The tables here detail the costs of all the renewable energy equipment. Bob-O and Kathleen have invested just about $20,000 in their electric renewable energy systems. While this sounds like a lot of money for power, let's examine the alternative.

Bob-O and Kathleen's property is located 1.7 miles from the end of the utility's power lines. The local utility, Pacific Power, charges $10.35 per foot for new line extensions. The going local rate for electric power is $0.095 per kiloWatt-hour. Bob-O and Kathleen consume an average of about six kiloWatt-hours daily. The table here compares the cost of running in the utility lines versus using renewable energy. This table does make some assumptions. One is that the renewable energy system lasts ten years, which is far more certain than the second assumption, that the utility will not raise its power cost in the next ten years. I figure that Bob-O and Kathleen saved more than $70,000 by using renewable energy for electricity.

If you consider that a new truck costs about twenty thousand dollars, it's easier to understand Bob-O and Kathleen's investment in self-sufficient and clean energy. In terms of performance for money spent, I pick an RE system over a gas guzzler any day.

Being here now

Bob-O and Kathleen live on an energy self-sufficient homestead. Their dedication to a sustainable future that all can share makes them friends of all living on this planet. I salute them!

The Utility versus Renewable Energy

Energy Consumption = 6 kiloWatt-hours daily
Distance from Utility Lines = 1.7 miles

Utility Power Cost

Line Extension Cost	$88,762
10 Year Power Bill	$2,081
Maintenance	$0
10 Year Cost	$90,842
$/kWh over 10 Years	$4.15

Renewable Energy Cost

RE Systems Cost	$19,207
10 Year Power Bill	$0
Maintenance	$875
10 Year Cost	$20,082
$/kWh over 10 Years	$0.92

RE saves Bob-O and Kathleen $70,760

Access

Author: Richard Perez, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179

System Owners: Bob-O Schultze and Kathleen Jarschke-Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 916-475-3402 Voice, 916-475-3401 FAX

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Converting a 12 Volt System into a 24 Volt System

Bob-O Schultze KG6MM

In the beginning it was a 12 Volt battery and a radio. And the radio begot the tape deck and rock 'n roll and it was good. And the tape deck begot taillight bulb lighting and the CB radio, which begot ham radios and electronics projects, which begot the 12 Volt soldering iron, flashlight battery rechargers, and 12 Volt water pumps for killer showers and it was getting really good. But not great.

Then came the small inverter which begot computers, TVs, bigger stereos, better lighting, small electric tools, motors, and blenders for making Margaritas. Then the need arose for more powerful inverters to run businesses, microwaves, toaster ovens, well pumps, and larger power tools to build bigger houses to shelter all this good stuff and the children begotten as a result of the Margaritas. And wisdom dictated that the universe be reconfigured to 24 Volts to run more powerful inverters while still providing 12 Volt for the many wonderful (and spendy) 12 Volt goodies. And it was great, but now we had a few problems.

The Reasons

Kathleen and I finally decided that we needed a sine wave inverter to run a laser printer and other goodies we'd been drooling over. I wanted a *big* inverter to run my air compressor and other power tools. The new Trace SW4024 seemed perfect. Sine wave *and* lots of "snort". But it required a 24 VDC input. At the same time, the Whisper 1000 was about to go in the air and the long wire run to the house called for either a higher voltage on the line or a spendy high power LCB. The handwriting was on the wall for a 24 Volt system.

The Problems

Over the years, you tend to accumulate quite a few 12 Volt goodies. Not only do these represent a fairly large investment, but most of the gear is high quality stuff and is more efficient to operate using DC than any available ac replacements. However, it's a good idea to re-evaluate each DC appliance in terms of value, life expectancy, overall system impact, and replacement cost of a comparable ac unit. In our case, the cost of buying a high power voltage regulator far outweighed the cost of replacing our 12 Volt RF-16 SunFrost and buying 117 vac power supplies for the ham gear. In different circumstances, where the major DC usage is lighting, for example, it may pay to replace older DC incandescent and fluorescent lamps and fixtures with some of the newer compact and circleline fluorescent lamps. If you make the switch, make sure that your wiring is up to snuff. Two conductor circuits without a separate ground work fine for low voltage DC loads, but won't be safe in a 117 vac circuit.

Additionally, all our RE sources had to be reconfigured to 24 Volt. The DC fusing and circuit breakers had to be sized down to reflect the drop in amperage.

Solutions

We bought a 20 Amp Vanner Voltmaster to power our 12 Volt loads from the 24 Volt battery bank. It has three inputs: –, +24, and +12. You tap half of your 24 Volt battery at +12 in addition to the major positive and negative 24 Volt connections. The Vanner monitors the voltage in both halves of the battery pack and electronically switches the load from one side to the other when a voltage imbalance occurs.

Rewiring the PV modules was easy and it actually eliminated a number of conductors, but it took some thought and different wire lengths to get the best configuration. Since the Wattsun tracker mounts the modules in two rows, it was possible to wire modules as pairs and parallel them as 24 Volt units. Running all the parallel connections at 24 Volts halves the currents on the wire and reduces line loss. The tracker to battery conductors were sized to carry twice the current at half the voltage than we had now, so the wire resistance and voltage drop went down significantly and we experienced a net gain in wattage delivered to the batteries. The conductors are 1/0 Cu wires with a one-way distance of 75 feet. Figuring an output of 36 Amps at 16 Volts at the modules, I calculated a 3.8% voltage loss from the tracker to the batts. Using 18 Amps at 32 Volts, the voltage loss drops to 0.9%. Under full sun conditions with the PV temperatures hovering at about 50°C, it roughly measures out to an extra 12 Watts. Free! Since my PV charge controller is a Heliotrope CC-60, all that was required was a flick of the DIP switch instead of control replacement.

With all the PV junction boxes opened anyway, it's a good time to inspect, clean, and tighten all the wire terminal ends in the array. How do those spiders and tiny buggers get into a sealed J box anyway?

The hydroplant alternator needed to be upgraded with a rewound stator to maximize output at the higher

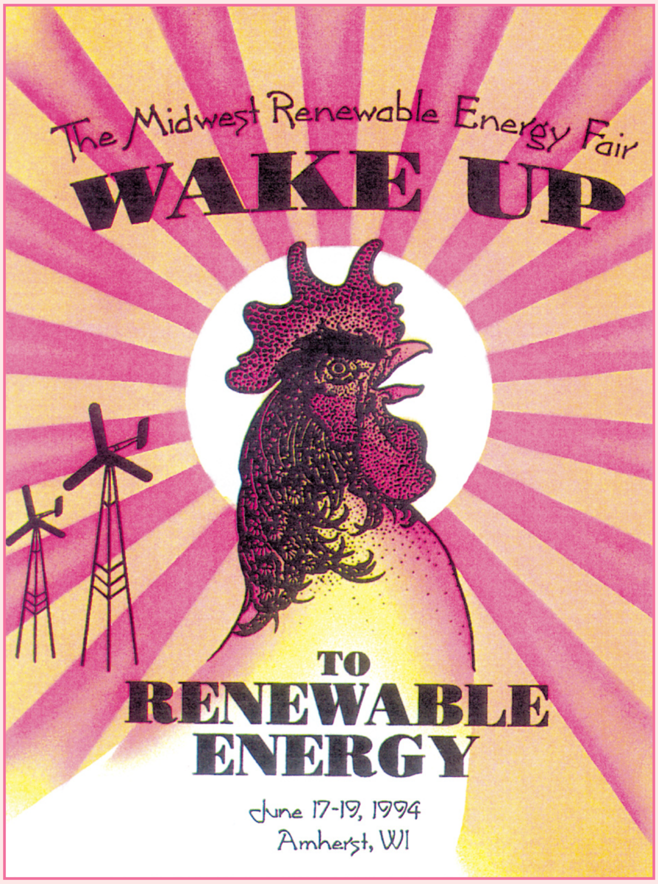
voltage. While the alternator was disassembled, we replaced the brushes, bearings, and polished the slip rings. Since the hydro lives at the creek and off the beaten path, none of this routine maintenance had been done in years. Finally, a "round tuit"! Yes, I know I'm supposed to be a professional, but did you ever see a mechanic's pick-up? Ugh.

The wind jenny was always set up for 24 Volt due to a long wire run. Converting to a 24 Volt system happened just before the tower went up and we were saved from buying an expensive linear current booster.

One of the most important things to do when making the change to 24 Volt is replacing the fuses and circuit breakers in the system with the proper values. In theory, that should be one-half the amperage rating of the old ones, but you know how that goes.... I found it was easier (and safer) to recompute the current flow of each circuit. Figure the maximum current flow (the short circuit current with PVs), add 25%, and round up to the next standard value. While you're in the fuse or breaker boxes, check for corrosion and retighten all the connections and lugs. Only takes a minute and who knows when you'll be in there again?

Access

Author: Bob-O Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 916-475-3402



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Time: 5:45 PM Title: Negawatts, Renewables, and Economics

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Home Power in Africa:

PV Field Training in Karagwe District, Tanzania

Mark Hankins

Photovoltaic (PV) technology is taking root in East Africa. In five years, more than 30,000 homes in Kenya, Uganda, and Tanzania have lit up with PV. Game parks use PV-powered fences and two-way radios, clinics use solar vaccine refrigerators and lights, while schools and businesses use PV for lighting, television, and radio. Cattle ranches, missions, and refugee camps use solar water pumps. Kenya alone has an installed capacity of over one megaWatt peak power. The market is expanding into Tanzania and Uganda, despite low incomes. Three quarters of the people here have little chance of being connected to grid power any time soon.

This rapid expansion of the solar market in Africa requires infrastructure to support PVs in the field. Technicians are needed to install systems and trouble shoot, educators are needed to teach about PVs, business people are needed to supply spare parts, manufacture components, and import decent equipment. In western Tanzania, the KARADEA Solar Training Facility is addressing this challenge. Last November it opened the first institution in the region exclusively devoted to training solar technicians.

KARADEA

Karagwe District is three hours by road east of Lake Victoria and just south of Uganda. The Karagwe Development Association (KARADEA) is a grass-roots community development organization located amidst fertile banana and coffee plantations atop the high ridges near the Rwanda/Tanzania border. KARADEA helps the inhabitants improve their lives through better use of local resources. Working chiefly with women's groups, it implements projects in rain catchment, afforestation, carpentry, appropriate technology, education, agriculture and credit. KARADEA also administers 5000 AIDS orphans. KARADEA's record over eight years, under Oswald Kasaizi's leadership, sets an excellent example of what a committed group of rural people with limited resources can do.

In 1988, KARADEA began selling and installing solar electric systems when a Swedish group provided the PV systems to raise operating capital. Over several years, dozens of donated single module lighting systems were sold to community members.

When I met Oswald at a 1992 Nairobi Solar Workshop, KARADEA had already installed over 50 lighting systems in homes, businesses, and the district library. He asked me and Harry Burris (long-time solar hand in Africa) to help KARADEA plan a solar strategy. We put together a PV program: to develop low-cost lighting systems for small businesses and homes, and train and support local people to install, maintain, and market systems. In July '93, CSC provided KARADEA with support to equip a training facility and to conduct an initial training course. The Solar Electric Light Fund contributed money enabling participation of two trainees from Maasailand, Tanzania.

People Demand Lights and Radio

But why "expensive" solar lighting? Why not PV water pumps, which could reduce the work load on the water bearers (women)? Why not solar cookers, which could reduce the work load on the wood fuel bearers (again women)? At this early stage in the solar industry here, mobilizing communities to finance and maintain "large" PV projects such as community pumps is difficult. So small systems make sense. A major issue with solar cooking is changing behavior. African women are as accustomed to managing wood-fired kitchens as we Americans are to our kitchen schemes. Even if it makes sense practically or environmentally, change comes slowly. (How many Arizonans cook using solar?)

People need electricity for lights and radios now. Lack of good lighting has deterred progress in literacy, health, and small enterprise. People need lights at night to read, study, and work. They need radios to keep up with events in the outside world, to enjoy music, and to listen to the World Cup.

In most of Karagwe district, grid power is not an option. The only power line reaches two towns (without juice

Above: Installation at Iteera by the KARADEA trainees.

as of December 1993) with no plans to run lines to the scores of outlying villages. TANESCO's (Tanzania's power monopoly) rural connection rate is not keeping up with population growth. In fact, rural electrificaton programs in sub-Sahara Africa have been spectacularly unsuccessful over the last 20–30 years. Less than 5% of rural families are hooked up to power lines. It's one thing to build a 180 MW dam and march the power into the city. It's another to distribute power to the 75% of the population that grow the cash crops and food. Distribution is an expensive nightmare.

Today, rural people light their houses with kerosene at $0.35 per liter. They buy dry cells to power radios, flashlights, and boom boxes at $0.70 per pair. Families end up spending a significant portion of their incomes on such "amenities". The attraction of replacing kerosene and dry cells with one's own harvested solar power is great — in Kenya, PV systems have sold by the thousands. Kenya's experience, and the interest generated by systems already installed in Karagwe, convinced us that PV lighting would succeed — and create jobs — in Karagwe.

Needing Technicians and Spare Parts Networks

Properly selected solar stuff — PV modules, box cookers, dryers, or water heaters — works well in the equatorial sun. However, setting up infrastructures to manufacture, market, and maintain these gadgets is quite challenging in cash-starved economies.

We in the west have been shamelessly airlifting engineers and parachuting imported equipment into Africa for decades and leaving it. In the past month, I've seen two multi-kilowatt PV projects that are derelicts baking in the African sun because donors — and the western consulting firms that installed them — did not plan sustainability into the program.

Home Power readers have long known what solar development workers in Africa are just learning. However good the technology, someone — preferably the end user — must be able to fix it. There must be a nearby source of spare parts. No matter how efficient, PL-type fluorescent fixtures are useless unless spare tubes are available, and unless someone can explain to customers why fluorescents are worth the extra cost. Otherwise they might as well come from the moon.

Unlike Kenya, Tanzania's PV "industry" is mostly donor-driven. Aid workers increasingly recognize the role of PV in off-grid areas. So Scandinavian development workers buy equipment from Scandinavian companies, Italian missionaries buy from

Below: Two KARADEA trainees, Rehema and Anna, fill batteries.

Italian companies, American Peace Corps buy from American companies and British buy from the British. International PV companies are fighting for project contracts and market shares in a battle which Tanzanians cannot afford. Companies fly in, make an installation, and fly out. Getting a contract is more important than developing the local industry. There are so many different types of controls, lamps, modules, wiring systems, pumps, and inverters that the local technician has little chance of making sense of the situation. During field visits to systems installed by Karagwe, I saw dozens of different light fixtures — baton lamps from China and Kenya, PL-lamps from Amsterdam, quartz halogens from the U.S., and incandescents. Customers have no idea where to get replacement bulbs, so they often replace burnt ones with less functional automotive fixtures. Hamstrung by a diverse and expensive range of imported solar equipment, local repair people can do little.

A sustainable supply network needs to be developed. Proper equipment needs to be chosen and imported, and links have to be developed to connect rural markets with the business centers (i.e., Dar es Salaam). Local codes and practices have to be developed. There must be some standardization of equipment, and international companies and projects must submit to these standards. Long-term maintenance contracts are needed. Marketing, installation and maintenance has to be handed over to local people — they need the jobs. So KARADEA's work is cut out for it.

Launching the Project

Karagwe is far from my base in Nairobi. With no fax, a mail service that often takes months, and skittish telephone lines, KARADEA has communication problems. So it took quite a few cross-border visits for Oswald Kasaizi and me to lay the project groundwork; we did much of the planning on-site using my solar-powered Macintosh PowerBook computer. We had to prepare a syllabus and bilingual resource materials. We had to select students, and to design and find customers for systems. We had to price equipment (locally and internationally), order it, and get it delivered. We had to overcome a variety of logistical crises — standard practice for a project funded from London, coordinated in Nairobi, and based in a district without electric power.

Our PV equipment arrived by air freight in Arusha from Neste Advanced Power Systems (NAPS) in Norway. However, three days before the training was scheduled to begin, Tanzanian customs was still sitting on the supposedly duty-free equipment. I nervously drove down from Nairobi with Frank Jackson (an Irish volunteer PV electrician) for the held-up PV modules, lamps, and controls. Luckily, Martin Saning'o (leader of a Maasai group) had, by hook and crook, negotiated the release of the equipment from Arusha International Airport Customs. Now we had to carry all 250 kilograms across hundreds of miles of parched savanna and Lake Victoria between us and Karagwe. The next morning Peter de Groot (project funder just

Low-Tech Tracking

At the equator, modules should be mounted flat — or almost flat — to receive the most radiation. Right? Well, this is generally true if the modules are mounted fixed. But give it some thought. Many northerners wrongly assume that the sun passes directly overhead in Equatorial Africa. Not true. From season to season the sun's incident angle actually shifts from 23°N to 23°S (it only passes directly overhead on March 22 and Sept 22). Each day it moves in a 180° arc from east to west. There is a low-tech way to get up to 30% more power from modules — or to reduce the number of modules required for a system — without having to invest in an imported tracker.

Harold Burris invented a rotatable pole tracking mount with the solar module(s) fixed on a frame 25° from horizontal. The pole is turned so that the module faces the position of the ten o'clock sun in the morning and again so that it faces the two o'clock sun in the afternoon. Pole trackers work well in

school and home situations where the task of rotating the module at noon and in the morning can be incorporated into the daily routine. An additional benefit of this tracker is that it keeps the modules cool and off the hot tin roof. We used rotatable pole tracking mounts on all of the KARADEA systems.

Above: KARADEA solar technicians: Dickson, Gaspar, and Farida.

arrived from London), Frank, Martin, two Maasai student technicians, and myself pulled out of Arusha in my junkheap Toyota Land Cruiser pickup loaded with PV equipment. We traversed the rim of the spectacular Ngorogoro Crater that afternoon. Then we got lost in the rainless Serengeti on a hellish night-time "game-drive" during which we dropped a muffler, unhinged the

Below: Oswald Kasaizi with solar customer.

air filter, and were chilled by the staring beady red eyes of various nocturnal beasts. Early in the morning the pickup limped into Mwanza where we booked a motel room and slept most of the day. That night, we ferried westward across Lake Victoria to Bukoba, where we spent another day — Peter recovering from dysentery and the car undergoing minor surgery on the carburetor and exhaust system. We made it to Karagwe a day late on a rainy Monday in November; eighteen students from Tanzania and Uganda were waiting for the course to begin.

The goal of the course was to build each student technician's skills so that he or she (four of the eighteen were women) could complete all the tasks required in a single PV module system installation. Each technician would be able to gather design information and to perform simple trouble shooting jobs. The training was loosely based on one Harry Burris and I gave in Meru District, Kenya in 1985. Morning sessions covered theory; afternoons were hands-on, either conducting practicals or visiting, installing and repairing systems.

The training staff included myself, Daniel Kithokoi (a graduate of the Meru 1985 training), Frank Jackson, Dickson Kawiru, Gaspar Makale and Oswald. Daniel and I were the chief trainers — he had arrived in Karagwe a week earlier from his home in Kenya to inventory equipment and to prepare sites. During the course, I covered theory while Daniel, who has hundreds of PV installations under his belt, led the practical work. Dickson, a teacher from the local polytechnic (he installed many of the KARADEA systems), volunteered as instructor and later as a team leader when we were laying wires and fixing lamps. Gaspar, the Solar Training Facility technician, didn't sleep from beginning to the end. He caught the bus to Bukoba to chase forgotten wire clips and screwdrivers, he supervised last-minute carpenters building battery boxes and sub-boards, he cleaned up classroom clutter, and he rigged the stereo system for the final party. Frank, now serving as a PV volunteer at KARADEA, thanks to the Solar Electric Light Fund, taught a few classes and played a critical role in the field practicals. Dickson and several students handled Swahili-English translations in the classroom, as about a third of the students spoke no English.

Students each received a tool kit containing digital voltmeters, assorted screw drivers, pliers, a hammer, insulating tape, a solar installation manual, training material in Swahili and English, and data collection forms. They had been selected to attend the course from several programs, including KARADEA's solar program, the Olkenerei Integrated Pastoralist Survival Program in Arusha, the Uganda Rural Training and Development Program, a solar company based in Musoma called Jua, Ltd., and the Ministry of Livestock's solar refrigeration team. Over 17 days, the students ate, drank, and slept solar. The course included an orientation to solar based rural electrification, and classes on the solar resource, PV, batteries, controllers, wiring, lamps and appliances, system

Kiosk Lighting, Radio, & Security Systems (6)

#	Equipment	Manufacturer	Model	Source
1	Photovoltaic module	Siemens	M-25, 22 Wp	Import
1	Tracking mount	KARADEA	Burris design	Karagwe
1	Lead-acid battery	Yuasa Tanzania	70 A-h at 12 VDC	Mwanza
1	Charge controller	NAPS	NCC-1 (5 A, w/LVD, indicators)	Import
2	Tube light	Thin-lite	8 W, 12 VDC	Import
3	Switches (w/ box)	Chinese	rated for 240 vac	Bukoba
1	Low voltage supply	Chinese	12 VDC 9/7.5/6/4.5/3	Bukoba
	Cable		2.5 mm^2 Twin w/o Earth	Bukoba
	Cable		6.0 mm^2 Twin w/o Earth	Bukoba
1	Socket outlet	Chinese	240 vac rated 13 A w/ plug	Bukoba
1	Security system		panic button/siren	Nairobi
1	Battery box	KARADEA	Burris design	Karagwe
1	Sub-board	KARADEA	Kithokoi design	Karagwe

maintenance, and basic system sizing. We also discussed small business/PV network development in East Africa. The class broke into small groups during practical sessions, which we integrated with theory.

The students got plenty of installation practice and exposure to PV. Each morning, they helped set out several small modules that charged solar lanterns, hand tools, AA-size nickel cadmium cells, and my PowerBook's gel cell. They critically examined systems in the town's post office, veterinary clinic, and library. Under the watchful eyes of the trainers, they rewired and installed switches in the hostel's solar electric system. With the instructors, they installed a 212 Watts peak (Wp) system at the training centre and a 53 Wp lighting/radio system at KARADEA's headquarters. Laying cables, placing switches, and fixing lamps was time consuming, and we would not have completed without after-hour efforts by Dickson, Daniel (who demanded perfection from the students), and a few dedicated students.

Solar Training Facility Workshop System

#	Equipment	Manufacturer	Model	Source
4	Photovoltaic module	Siemens	M-55	Import
1	Tracking mount	KARADEA	Burris design	Karagwe
4	Lead-acid battery	Yuasa Tanzania	100 A-h at 12 VDC	Mwanza
1	Charge controller	NAPS	NCC-2 (24 A chg, 30 A load, LVD)	Import
5	Tube light	Thin-lite	8 W, 12 VDC	Import
6	Tube light	Thin-lite	8 W, 12 VDC	Import
2	Security light	Thin-lite	9 W, 12 VDC	Import
11	Switches (w/ box)	Chinese	rated for 240 vac	Bukoba
2	Low voltage supply	Chinese	12 VDC 9/7.5/6/4.5/3	Bukoba
	Cable		2.5 mm^2 Twin w/o Earth	Bukoba
	Cable		6.0 mm^2 Twin w/o Earth	Bukoba
12	Socket outlet	Chinese	240 vac rated 13 A w/ plug	Bukoba
1	Main switch	Chinese	2 way	Nairobi
1	Security system		panic button/siren	Nairobi
1	Battery box	KARADEA	Burris design	Karagwe
1	Sub-board	KARADEA	Kithokoi design	Karagwe

On one diversion from the schedule, Oswald took the students on a much-appreciated day trip to the Biharamulo Game Reserve. Surprisingly, many of the students — especially those from Uganda — had never seen wild animals before. When they repaired his PV radio system, the park warden rewarded the students by shooting a topi (a large antelope) and loading it into the Land Cruiser. We ate well over the next two days under the solar light of the hostel's dining room.

In the last week students were split into four teams and given a field practical exam, which would make up a third of their final mark. They were sent into villages to install 22 Wp lighting systems for kiosk businesses (table top left). Daniel, Frank, Dickson and I watched and marked (without offering assistance, correcting as necessary) as the four teams fixed systems. By the evening there was electric light in four villages which had not known electricity before. On the second to last day of the course, the students were given a final exam with theory questions and practical exercises.

All 18 students passed the course and marks were high. Even if the exams were a bit too easy this time, the good marks were testament to the seriousness of the students and their committed interest. I was especially pleased with the work of the women in the group. Nkurunziza Immaculate of URDT was at the top of the class, and Farida Katunza of KARADEA was up in the dusty crawlspaces laying wire long after most of her male counterparts were too beat to continue.

Village Home Power Systems

When designing the nine systems to be installed by the class, we had three over-riding objectives: reliability, low cost, and the use of local equipment whenever possible. The 212 Wp

system at the Training Facility (pg. 24, bottom) would be used for lighting and powering small tools in its workshops. The two 53 Wp systems were for lighting, laptops, and office equipment in KARADEA and URDT offices (see table below). Six 22 Wp systems would light two rooms and power radio/cassettes in village kiosk businesses (pg. 24, top). All of the systems included button operated security lights and sirens.

Use of local spares was a departure from earlier KARADEA practice. The one-panel systems they had been installing had been bought off-the-shelf in Sweden and crated — wires, bulbs, switches and batteries all — to Tanzania. Because systems arrived complete, the KARADEA technicians had not previously investigated the prices and availability of local parts. So, Daniel and Gaspar scoured electrical and automotive shops in Bukoba and Mwanza for parts. In the project's nine installations, we used locally-purchased tools, switches, outlets, low-voltage supplies, wires, security systems, and automotive batteries. We also built what we could on-site from local raw materials, including the tracking mounts, battery boxes, and sub-boards in KARADEA's shops.

A number of design compromises were made. We ran all the systems at 12 Volts and stayed away from inverters — the Training Facility's electric tools are all 12 Volt. Without a local supplier, an inverter would be hard to replace or repair. We used locally-made heavy duty truck batteries instead of deep discharge batteries. Such local automotive batteries have short lifetimes, but they're much less expensive than imported ones. If the PV revolution is to continue in Africa, somebody's got to manufacture a decent deep discharge battery.

KARADEA & URDT Headquarters Systems (2)

#	*Equipment*	*Manufacturer*	*Model*	*Source*
1	Photovoltaic module	Siemens	M-55	Import
1	Tracking mount	KARADEA	Burris design	Karagwe
1	Lead-acid battery	Yuasa Tanzania	100 A-h at 12 VDC	Mwanza
1	Charge controller	NAPS	NCC-1 (5 A, w/LVD, indicators)	Import
4	Tube light	Thin-lite	8 W, 12 VDC	Import
1	Security light	Thin-lite	11 W, 12 VDC weather-proof	Import
8	Switches (w/ box)	Chinese	rated for 240 vac	Bukoba
1	Low voltage supply	Chinese	12 VDC 9/7.5/6/4.5/3	Bukoba
	Cable		2.5 mm^2 Twin w/o Earth	Bukoba
	Cable		6.0 mm^2 Twin w/o Earth	Bukoba
1	Socket outlet	Chinese	240 vac rated 13 A w/ plug	Bukoba
1	Main switch	Chinese	2 way	Nairobi
1	Security system		panic button/siren	Nairobi
1	Battery box	KARADEA	Burris design	Karagwe
1	Sub-board	KARADEA	Kithokoi design	Karagwe

We imported fluorescent lamps, controls, and PV modules. Although several companies manufacture lamps in Kenya, experience with their units has been mixed. We didn't want to let lamps be the weak link; better to demonstrate quality lamps that don't blacken bulbs or interfere with radio reception. We chose baton-type lamps because spare bulbs are available in Bukoba and Mwanza. We used the same NAPS charge controllers that had been installed earlier in other KARADEA systems — NCC-1's are adequate and we saw no need to change. They give the user a rough idea of the battery's state of charge, they're fused, they have master switches, and they tell the user whether the module is producing power. We should have asked the factory to set the low voltage disconnect a bit higher because they're protecting automotive — not deep discharge — batteries.

We used Siemens M-55 and M-25 PV modules. A problem with crystalline modules is that they get scandalously expensive at smaller sizes. For the kiosks, we needed 20 Wp modules. Small shops simply can't afford 50 Wp systems. Faced with the choice of crystalline at $11 per peak watt or amorphous (Chronar-type) modules at $6.50 per peak watt, we chose the crystalline because of its proven quality. But still, $220 for a 22 Wp module is steep, and unless a reasonably priced crystalline type becomes available, amorphous dealers will swamp the market.

Supporting the Network — PVs for Tanzanians

Now that they've been trained, we're trying to keep this small group of solar pioneers supported. Immediately after the training, Frank Jackson safaried with the Uganda Rural Development & Training (URDT) to help them complete their installations (a 53 Wp system at URDT's offices and two 22 Wp lighting systems in kiosks) in Kagadi, Uganda. Meanwhile, Peter de Groot, the Solar Electric Light Fund, and I are trying to keep funding in the pipeline for more training, business support, and seed credit funding — especially for women. We *are* holding a CSC-sponsored training at KARADEA June 5–26, 1994 despite Rwandan refugees moving through Kagera. Daniel and my company, Energy Alternatives AFRICA, will be taking on at least one of the trainees as an intern so that he can learn about the Nairobi solar industry.

Few people can afford to pay the up-front costs of PV systems. Even if financing were available, many people would still not be able to purchase the

Above: The KARADEA Solar Training Facility, a locally organized and financed group, trains the people who will determine rural Africa's energy future. Their energy independence and determination demonstrates real energy solutions to real power problems. These folks work and know what works!

"standard" 50 Wp systems — $1000 is more money than most see in a year. Cash is hard to come by and the terms of trade are stacked against small farmers in Africa. Although only "wealthy" individuals can afford 50 Wp systems at present prices, PV lighting is viable among high-income groups, businesses, and institutions who have no power alternatives. The introduction of an infrastructure to support PV for the above groups — and for the hundreds of vaccine refrigeration, pumping, lighting and two-way radio systems already in place — will inevitably make smaller 5–20 Wp systems more available and less costly.

Smaller systems and credit are needed to keep the commercial market in East Africa on its feet. We had several types of solar lanterns at the training. At about the price of a bicycle, these were items that many villagers wanted and could buy. But solar lanterns are not widely available (if you know of a decent unit, please let me and KARADEA know!!).

PV's role in rural development in Africa is growing. Village homes, businesses, and institutions need the power that PVs can provide. Unlike kerosene, diesel, or mega-dam power, each PV system installed in Africa increases the resources of the village and makes it more self-sufficient. Sun-electricity beats inflation and currency devaluation. PV energy means jobs for installers and spare parts suppliers, and for the people who can work and study longer under electric light. In Karagwe, it is a cornerstone for rural empowerment.

Access

Mark Hankins, PO Box 76406, Nairobi, Kenya. Tel/Fax: 254-2-729447. Mark Hankins has participated in the development of solar markets in East Africa over the past ten years, starting as a Peace Corps science teacher and now as co-director of a Nairobi-based company called Energy Alternatives AFRICA.

Oswald Kasaizi and Frank Jackson, KARADEA, PO Box 99, Karagwe, Kagera, Tanzania. KARADEA needs financial support to buy and maintain a vehicle and piki-pikis (motorcycles) to better service systems in the area. If you can help, contact Frank Jackson.

Above: The solar bakery in Villaseca, Chile. The ovens are closed between batches so they won't overheat.

Hot Times in Chile

Jay Campbell

Chile is a fascinating country. Stretching all the way from the tropics to the south pole, it holds samples of every climate zone possible. The beauty of the land is simply stunning — you are never very far from either the rocky coastline or the impenetrable Andes mountains. The northern region is much like the desert in the southwestern United States. Rolling hills are covered with cacti and small scrub brush. Sand dunes dot the landscape as you wind your way north from the busy capital of Santiago.

Just a century ago, this area was heavily wooded, rich with plants and animals. Unfortunately, whole valleys were denuded to fuel the copper smelters and steam locomotives that made Chile strong. The process of desertification is continuing, each year creeping further into the beautiful valleys. The remaining scrub growth is all that is left for use. Each year life becomes a little harder for the people of the region as they spend more time and money to gather less and less fuel.

One village, however, is winning in the battle against the relentless desert sands. In Villaseca (literally "dry village"), a hundred families are carving out a sustainable way of life, and building a stronger economic future in the process. Their weapon of choice? Bright orange solar ovens, quietly utilizing the one over-abundant resource.

Sunshine to the Rescue

A recent trip took me to Villaseca to work on a solar oven design project. Walking through the dusty streets

Top Right: One of the most enthusiastic supporters shows off her lunch (soup).

Center Right: A kindergarten class responds when asked, “How many of you have solar ovens at home?”

Bottom Right: Pedro Serrano, the designer of the Villaseca parabolic cooker, shows off its power.

was a thrill for an oven promoter like me — solar ovens were everywhere, quietly serving their masters in the desert sun. Over two-thirds of the families in Villaseca rely on solar cooking daily. The wide variety of foods they fix — soups, squash, rice, beans, and breads — speaks to the versatility of their ovens.

Ah yes, the breads. In the past, bread was never made in Villaseca, due to the large amount of wood and fire tending it required. With the introduction of solar ovens, however, the locals have gone bread crazy. Fresh bread is so good and so inexpensive that it is now standard fare. One enterprising family has even invested in five ovens, and runs a solar powered bakery! Their bread is sold locally and in nearby towns, providing them with a nice source of income.

About five years ago, a dedicated group of professionals from the University of Chile set out to make solar ovens happen. Beginning with literacy and nutrition training, they progressively introduced an awareness of the environment, economics, and options available to the people. Only after a year of work did they mention solar cooking. They developed a couple of designs, and taught how to build and use them. Another two years passed before they felt that the project had been a success and had taken on a life of its own. Since then, the momentum has continued to build.

People are truly excited about the changes solar cooking has brought to their lives. The reduced costs in time and money have translated into a higher standard of living. Although Villaseca is still a humble village, people can afford to pour concrete over their dirt floors, put glass in their once open windows, eat more and better food, and provide other substantial improvements. Their

one time investment of time and money is paying real dividends every day.

Health has improved by the upgrade in their diets and the reduction of the hazards of wood cooking. People have more time, which they have used for learning new skills, for productive endeavors, and for better child care. Several people use their time to make and sell crafts. The mothers have organized a cooperative school/day care facility. The skills they learned to make ovens are also being used to build furniture and do home improvements. The women's cooperative even makes and sells ovens to nearby villages.

Two different solar cooker models are used in Villaseca. The most common is an insulated wooden box with four flat reflectors on top. This oven is used for baking and for simmering foods throughout the day. The other common cooker model is a one meter parabolic dish, which cooks as if it were a gas range. This impressive cooker is great for boiling water quickly and for frying. It requires someone to monitor it, due to its high power, whereas the box ovens can be left unattended for hours at a time. The people have adapted their recipes well to these cookers, and are quite proficient in their use.

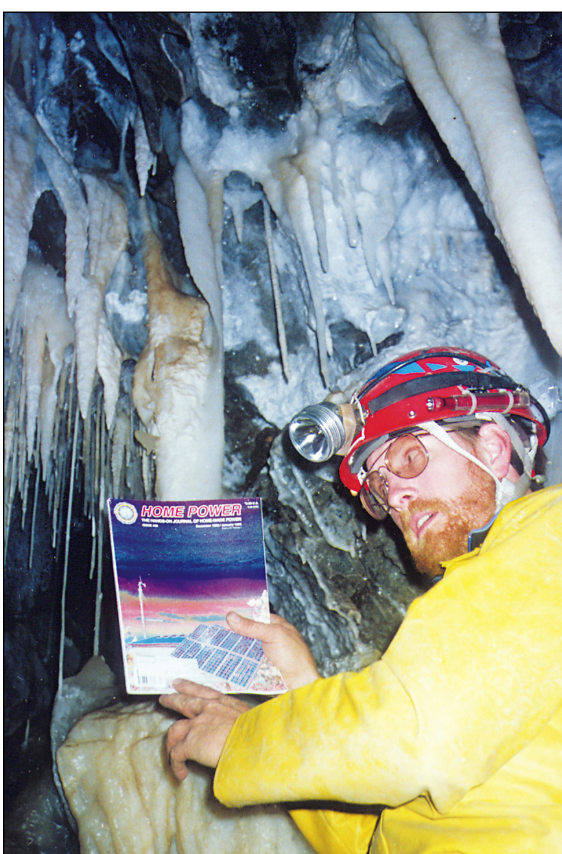
The Big Picture

The community as a whole is much stronger as well. The time and money freed up by solar cooking has stayed in the village, improving everyone's lives. People are more able and willing to help each other out, to share with one another. They are planting trees throughout town, and steadily upgrading the town square and soccer field (every village has one!). The people have drawn together with their accomplishments, and revel in the interest and respect that outsiders show. Although Villaseca is so small that it has never appeared on a map, the people's accomplishments are known far and wide.

I have long known the benefits a solar oven can provide to anybody who uses one. The beauty of Villaseca is the synergy created by so many ovens in one small area. The benefits compound one another, and the whole is worth far more than the sum of the parts. This humble village has shown what a group of people can accomplish when they work towards a challenging goal. They are leading the way for all of us, taking the idea of sustainability to a new level, and prospering from the rewards. If this is a glimpse into our own sustainable future, solar cooking will be worth all of our efforts. ¡Viva el sol!

Access

Jay Campbell, Applied Engineering, 218 Dartmouth SE, Albuquerque, NM 87106 • 505-848-7674



4/2/94

Dear Home Power Crew,

I recently went on a cave cleanup trip in Sequoia National Park. I could not go a day without reading HP so I took my latest copy with me into the cave. It survived three vertical rappels, a mile of being dragged in a pack through tight passages, over rocks and mud. Just to prove this we took some photos. I better check to make sure my subscription is still good. The label is still on and it looks like I'm good for another year. I'm enclosing some photos. Please feel free to use them in my favorite magazine, HP. Keep up the good work!

Regards, Rick A. Niemi, PO Box 13152, Coyote, CA 95013

Wow, Rick. By way of thanks, we've added another year to your subscription. HP

Above: A home in western China gets electric power from a single photovoltaic module mounted on a pole in the courtyard. Photos by the Solar Electric Light Fund

An Illuminating Success

The MaGiacha Village PV Pilot Project, Gansu Province, China

Neville Williams

With an invitation in hand from the Gansu National Energy Research Institute in Lanzhou, China, I made my first visit to Gansu Province in 1992 to help develop a pilot solar rural electrification project. I had not been in China since 1979, and the changes in 13 years were mind-boggling. Perhaps no other country has undergone such profound self-induced transformation in such a short time.

Prosperity and hope for a better life are in the air. Even in the countryside, the economic boom is apparent. And yet many farmers — China has 950 million of them — cannot enjoy the fruits of the market economy because they have no electricity. Although China has electrified 85% of its people, several hundred million are still beyond reach of the electric grid. The government does not want to abandon these people to the “kerosene age”. Solar activists in China believe photovoltaics could propel as many as 20 million families, or 100 million people, directly into the solar age. Our small, Washington DC-based non-profit organization, the Solar Electric Light Fund (SELF), was asked to help in one poor, distant, sunny province: Gansu, on the Silk Road, 1200 miles west of Beijing.

Financing is the Key

Our project was launched in collaboration with our PV supplier and project contactor, the Gansu GNERI PV Company (GGPV) of Lanzhou, an "economic unit" that has been "spun off" from GNERI. We selected an unelectrified village, known as MaGiacha, of some 850 people (around 200 families) in Tongwei County, Dingxi District, Gansu Province. One hundred families quickly signed up to purchase 20 Watt peak solar electric systems, agreeing to pay RMB Yuan 300 down ($55) and 10–30 Yuan ($2–$5.25) per month for 3 to 10 years at zero interest.

SELF has organized solar loan schemes in Sri Lanka and Nepal, and is currently developing similar projects in India, Vietnam, and Africa. Credit mechanisms vary and collections are flexible, recognizing the seasonal nature of family income. SELF's local partner, usually a non-government organization, collects the money and deposits it into a revolving fund used to provide additional solar loans to the local community. The goal is to create institutional models that will lead to the creation of large district, province, or even national revolving solar loan funds financed by the government and development agencies.

Below: PV modules need to be wiped clean of the *loess* dust which accumulates rapidly in western China.

A Leap of Faith

While the villagers of MaGiacha wanted electricity and were willing to pay for it, they did not want to pay more than the cost of the heavily subsidized grid electricity. Had the grid been available, electricity would have cost them only 10 Yuan ($2) per month. Nor could they be expected to pay for a technology they knew nothing about and had no reason to trust. Nonetheless, they were willing to be "solar pioneers", and blindly put down their $55 down payment — an immense sum to them — on a home solar system that would provide power for electric light, television, and radio. They made this economic "leap of faith" because they knew their village would not be considered for grid extension for at least another ten years, if ever.

The village leaders themselves had done a cost analysis comparing solar electrification with grid extension. They looked at the cost of a main transmission line, transformer, line network, hookups, meters, etc., and determined the village could not afford to pay its share, as required by the authorities. At the same time, they were initially not willing to pay more for alternative power from an unproven source — the sun.

Below: The 20 Watt PV systems provide power for three lights. Some choose to locate one outdoors.

Above: Professor Wong (right) and his son show charge controllers developed by their company, Gansu GNERI PV Co.

A Working Demonstration

SELF demonstrated solar to the villagers by donating two demonstration PV systems in July 1992 which worked flawlessly throughout the winter. Because of this success, SELF decided to use similar systems for the entire project. All systems were developed locally by the Gansu GNERI PV Company of Lanzhou. They are entirely Chinese-made. The solar module itself is produced by the Hua Mei Photovoltaic Company of Qinghuangdao, using American Spire equipment.

With support from the Rockefeller Foundation, 100 household solar electric systems were purchased by SELF and installed between April and July, 1993, in MaGiacha. Twelve more have been purchased out of the down payments to the revolving fund. Each system includes three 8 Watt DC fluorescent light fixtures, a 38 Amp-hour deep-cycle sealed lead-acid battery, a charge controller with LED indicator lights, volt and amp meters, a 9 Volt outlet for radio-cassette players, wiring, switches, and mounting hardware. The PV mounting bracket, which sits atop a wooden pole provided by each farmer, can be adjusted seasonally. Each system costs $375.

Bright Lights and Fresh Air

The people of MaGiacha are very excited to have electricity for the first time. They have retired their kerosene lamps and 20 families have bought 19 inch black and white televisions. They are grateful for the assistance in bringing electric light to their “forgotten” village. As one villager stood up and said at a public meeting, “Not long ago we only had kerosene lamps, which gave us a little light, like the stars do. It’s so difficult for us to do any work in the evening time. The most dangerous thing was when we got up in the morning, our noses and mouths were filled with black ashes. If one continually worked for four or five hours under the kerosene lamp, he must feel dizzy in the head and dim of sight.

“Now there is bright light in the houses, with fresh air! If you are on the way to MaGiacha, you may notice the change and wonder if it is a ‘city’, for the bright lighting, beautiful music from the TV mixed with the talk and laughter of people will give you a picture of a ‘city’.”

A 99% Instant Success

We sent SELF’s Deputy Assistant for China, Mrs. Mao Yinqiu, an electrical engineer and PV expert, to spend a week in MaGiacha last winter monitoring the project. She found only one problematic system, which was replaced. All other systems were working fine as long as the householders remembered to wipe the snow off their panels! The solar electric systems provided three hours of light and several hours of TV per night. Only twelve fluorescent tubes have burned out, which doesn’t provide much work for Mr. Ma, the technician SELF trained to look after maintenance of the systems. Mr. Ma has spare parts, bulbs, and a complete set of tools, including a multi-meter. (SELF trains technicians for all its projects. We hope they become like the Maytag repairman, in which case they can concentrate on selling and installing systems as a dealer’s local representative, instead of repairing them.)

The Future

Because Tongwei County is the second poorest county in China’s second poorest province, the local government assisted the project by providing a 25% subsidy to the users. SELF asked the authorities to cost-share a 1000 house project now under development in the seven counties of Dingxi District. To manage this program, an affiliate of SELF has been organized called the Gansu Solar Electric Light Fund, or G-SELF, with its own board of directors and official registration. G-SELF now manages SELF’s revolving credit funds for MaGiacha and the Seven Counties PV Project, which is funded in part by the Rockefeller Brothers Fund and the W. Alton Jones Foundation.

Meanwhile, the United Nations, noting that, “Household PV systems are the only practical possibility for providing basic electrical services for more than five million families in Western China for whom access to electric power is not likely in the foreseeable future,” has recommended a U.S. $7 million solar electrification

project for Gansu. This project would be based on SELF's model and could service 40,000 homes.

The MaGiacha project has succeeded in field testing and demonstrating for a wide audience the affordability, reliability, and simplicity of the local company's new solar home systems. As the UN briefing paper put it: "Their quality and reliability has been consumer tested and is equal or superior to that of any PV kits available on the international market."

Building on this catalyst PV project, SELF has signed a joint venture contract with the Gansu GNERI PV Company to produce household solar electric power and lighting systems for the Western China market. SELF owns 49% of the joint venture, called the Gansu PV Company. G-SELF, with support from the Chinese government, owns 51%. This capital investment project is also supported by the Rockefeller Foundation. Any profits that SELF should see from the joint venture will be recycled into other solar energy projects.

Demonstrating a new way to bring power to the people, MaGiacha has proven the concept of household solar electrification and energy SELF-reliance in rural China.

Access

Neville Williams, President, Solar Electric Light Fund, 1739 Connecticut Ave NW, Washington, DC 20009

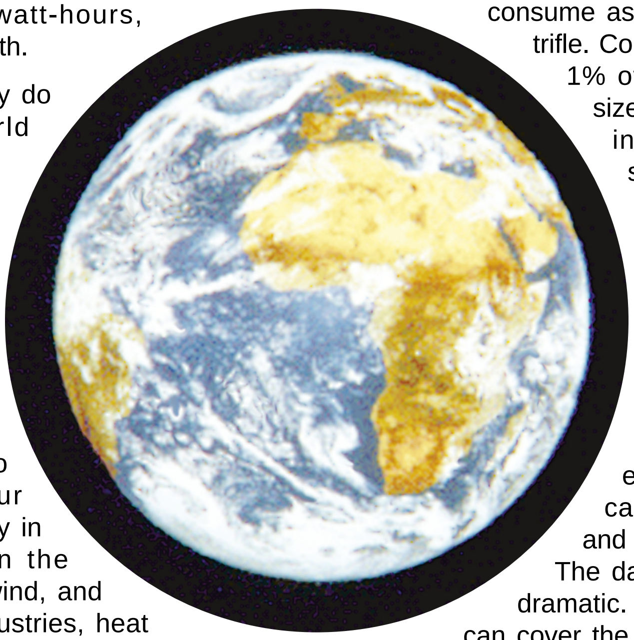
Above: The Solar Electric Light Fund helps local companies and solar experts power local homes with local capital.

The Solar Electric Light Fund, a non-profit charitable organization, was founded in 1990 to promote, develop, and facilitate solar rural electrification and energy self-sufficiency in developing countries. SELF's work is supported by foundations and individual contributors. Donations to the Solar Electric Light Fund are fully tax deductible.

The National Renewable Energy Laboratory (NREL) is one of ten federally funded national laboratories. NREL has offered to provide answers to technical questions Home Power readers have regarding renewable energy.

Question: How much solar energy strikes the earth?

Answer: The sun generates an enormous amount of energy — approximately 1.1 x 10^{20} kilowatt-hours every second. (A kilowatt-hour is the amount of energy needed to power a 100 watt light bulb for ten hours.) The earth's outer atmosphere intercepts about one two-billionth of the energy generated by the sun, or about 1500 quadrillion (1.5 x 10^{18}) kilowatt-hours per year. Because of reflection, scattering, and absorption by gases and aerosols in the atmosphere, however, only 47% of this, or approximately 700 quadrillion (7 x 10^{17}) kilowatt-hours, reaches the surface of the earth.



Question: How much energy do the people of the world consume?

Answer: Solar energy runs the engines of the earth. It heats its atmosphere and its lands, generates its winds, drives the water cycle, warms its oceans, grows its plants, feeds its animals, and even (over the long haul) produces its fossil fuels. It also runs the engines of our economies and of our society in general. We depend upon the energy from plants, water, wind, and fossil fuels to power our industries, heat and cool our homes and business, and run our transportation systems.

All told, the people of the world buy, trade, and sell a little less than 85 trillion (8.5 x 10^{13}) kilowatt-hours of energy per year. But that's just the commercial market. Because we have no way to keep track of it, we are not sure how much non-commercial energy people consume: how much wood and manure people may gather and burn, for example; or how much water individuals, small groups, or businesses may use to provide mechanical or electrical energy. Some think that such non-commercial energy may constitute as much as a fifth of all energy consumed. But even if this were the case, the total energy consumed by the people of the world would still be only about one seven-thousandth of the solar energy striking the earth's surface per year.

Question: What about the United States?

Answer: Along with the people of Canada, we in the United States are the energy consuming champions of the world. As a nation, we consume roughly 25 trillion (2.5 x 10^{13}) kilowatt-hours per year. This translates to more than 260 kilowatt-hours per person per day — this is the equivalent of each of us running more than one hundred 100 watt bulbs all day, every day. Per person, we consume 33 times as much energy as the average person from India, 13 times as much as the average Chinese, two and a half times as much as the average Japanese, and twice as much as the average Swede.

Yet, compared to amount of solar energy falling on the land mass of the United States, the energy we consume as a nation could appear a mere trifle. Consider: if we set aside less than 1% of our land (an area about the size of two or three large counties in Nevada) and installed solar systems (such as solar cells or solar thermal troughs) that were only 10% efficient, the sunshine falling on these systems could supply this nation with all the energy it needed.

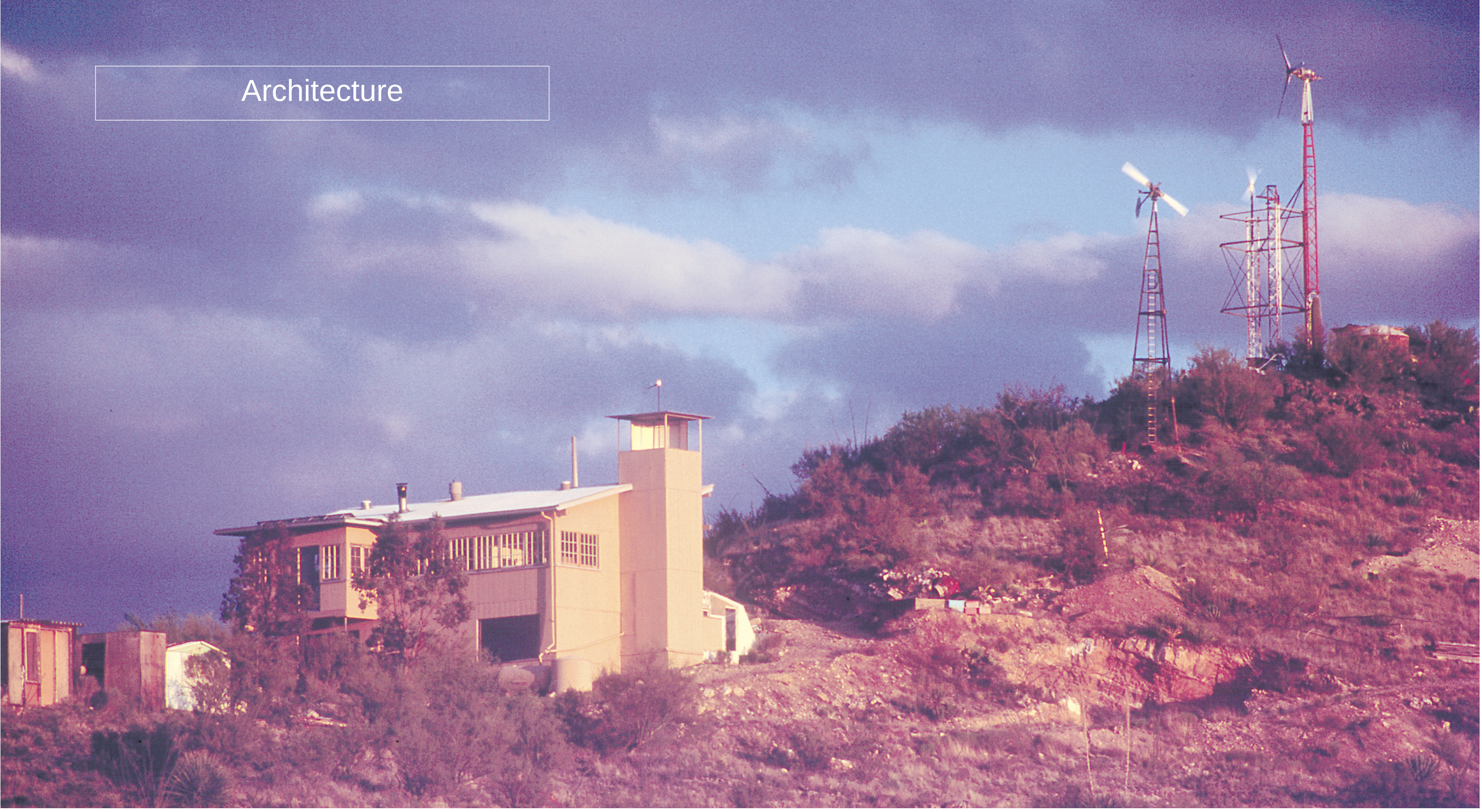
In a certain sense, this is impractical — besides being extremely expensive, you just can't take two or three counties and cover them with solar systems. The damage to ecosystems might be dramatic. But the principle remains. You can cover the same total area in a dispersed manner — on buildings, on houses, along roadsides, on dedicated plots of land, etc.

In another sense, it is practical. We already dedicate more than 1% of our land to the mining, drilling, converting, generating, and transporting of energy. And the great majority of this energy is not renewable on a human scale and is far more harmful to the environment than solar systems would prove to be.

Access

Author: Gary Cook, NREL

Send your technical renewable energy questions to: NREL, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179 voice or FAX



Above: The cool tower keeps Charles Van Meter's house cool all summer long.

How to Stay Cool in the Hot Desert

Charles Van Meter

When the thermometer starts to hit 90°F nearly every day, even though "it is a dry heat" as we say here in the desert, we start thinking seriously about ways to stay cool. More than 14 years ago when we were planning to build a renewable energy powered home, cooling our home was the big question.

We had no doubt our new home, to be constructed on a 20 acre hilltop near Vail, Arizona, would be powered with wind and solar. We chose the site with wind power in mind. The domestic hot water system would be a passive solar system. We would use solar for space heating the structure, but how do we cool the home using renewable energy?

No Information on Low Energy Cooling

Air conditioning is not practical for a renewable energy (RE) powered home because the compressor and blowers consume a lot of energy. Evaporative coolers work well and use considerably less energy, but the blower still requires lots of energy. Plenty of books and information discuss all types of solar heating, but little to none describe passive or low energy use cooling.

I first thought about building most of the house underground. After choosing a site on the property to construct the house, I realized that excavating and removing the rock at the site would be difficult. Secondly, an underground house would deny us the outstanding views at the house site. We decided to build at a different site on the property. The house would be a two story structure. The downstairs would be mostly (80%) earth-sheltered, and the upstairs completely above ground with many windows.

Underground Cooling Tubes

The downstairs would not require much cooling because it is thermally connected to the earth, but the upper portion of the house would require considerably more cooling. I had researched underground cooling tubes and thought this could be part of the answer. I would feed air through a tube about 150 feet long and

two feet in diameter. The air would pass through an evaporative cooler pad as the air entered the house. This cooler would be located underground. To move the air I would use an upwind air scoop at the cooling tube's intake. A solar chimney at the top of the house would help move the air through the house. No blowers would be required to move the air. So I started digging the ditch for the cooling tubes. I soon found the rocks that I had abandoned at the other higher site had deep roots. In addition I still had to come up with a material for the tubes: it had to be rust proof, a good heat conductor, the proper size, workable, and affordable.

Finding A Better Way

The ditch and the search for the tube material became an ongoing project. Then one day, about three years into the search, I stopped by the Environmental Research Lab where a friend, Bill Cunningham, worked as an engineer. He told me about a low energy use passive cooling system — cool towers. A cool tower requires no blowers or fans to move the cool air. The only power required is for a small DC pump to circulate water over the pads. A cool tower seemed the perfect answer for cooling an RE powered dwelling. From that day on, some major design changes took place in the already half completed structure. The solar chimney planned for the west end of the house changed to a cool tower. We filled in the mini Grand Canyon (the ditch) and avoided many hours of digging.

Normal Evaporative Cooling

Folks that live in places other than the desert may not be familiar with an evaporative cooling system. Blowers are used to move air through wet pads. As the air flows through the wet pad, water evaporates and cools the air. You cannot recirculate this air because the humidity increases and evaporation stops. At that point your evaporative cooler becomes a humidifier only. With evaporative coolers you must leave an exit for the air to escape from your house. Many newcomers to the desert don't realize you must open a window to make an evaporative cooler work properly.

How Cool Towers Work

Cool towers operate on the same principle as a standard evaporative cooler. The magic starts with the way the air is moved. Special pads made of CEL-dek sit at the top of a tower with a pump recirculating water over these pads. Air passes through the special pads with little resistance and is cooled by evaporation of the water. This cool moist air is heavier than the hot dry outside air and drops down the tower and into the structure to be cooled.

In order for the cool air to flow in, hot air must be exhausted from the structure. Open windows exhaust

Above: The upwind scoop on the cool tower guides hot dry air past the wet pads. Water evaporates, and the moist cool air drops down inside the house. Downwind scoops on the roof exhaust warm air.

this air with conventional evaporative coolers. If the wind blows hard against the side of the house with the open windows, the cool tower air flow will be reversed: no cooling. A large solar chimney can be used to exhaust air from the structure, which eliminates constantly watching the wind and opening the appropriate windows on the lee side. Downwind scoops are another alternative.

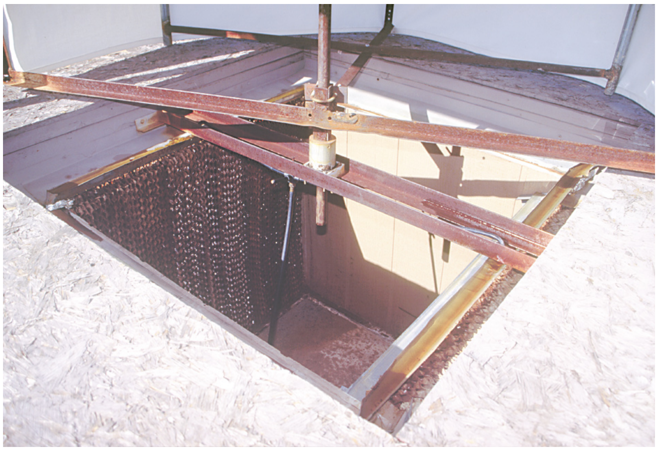
The Normal Cool Tower

Most cool towers have the pads around the very top of the tower. They use baffles inside the pads to keep the wind from blowing through the pads and out the other side.

My Cool Tower

I never do anything the way most people do a similar task. Maybe my situations are always different. I wanted to reduce the cost of the system as much as possible. The pads are expensive, so the fewer pads used that still accomplished the job, the better. I also used some cooling tube ideas in the design of the cool tower. Since the wind blows at a good steady pace here most of the time, I wanted to use wind power directly to help move the cool air through the house.

To create the additional flow down the cool tower I installed one large upwind scoop above the pads in the cool tower. This is an air scoop with a tail to keep the



Top: Wind both powers Charles' home and cools it off. The upwind scoop is made of a 72 inch wide by 39 inch high welded steel frame covered with canvas.

Bottom: A 12 Volt pump sends water cascading over the two CEL-dek pads. Collected rainwater leaves little mineral deposits on the pads when it evaporates.

scoop oriented into the wind, thus creating a positive pressure. Instead of one large outlet for the hot air, like a solar chimney, I installed smaller openings in the roof with downwind scoops to help remove heat. With these scoops the wind can blow from any direction and the cool tower continues to work properly.

On my design the pads are just below the scoop. This reduces the size and area of the pad, thus reducing cost. I have 18 square feet of four inch thick pads in my tower. Placing pads at the top of the tower would have required 72 square feet of pads. Pads down below the scoop are protected from direct sun, so they last longer. The tower itself is six feet square and 27 feet tall. The air scoop occupies the top three feet. Two pads three feet square by four inches thick are located just below the air scoop. Just below the pads is a tank containing 20 gallons of water with a float valve keeping this tank topped up. Located outside the tank is a small 12 Volt Teel bilge pump. This is a submergible pump, but I found the hard way not to submerge this pump. The first pump only lasted two months. The replacement pump mounted outside the tank lasted six seasons.

Some General Design Rules

I am not an engineer. I build things by what many refer to as "back yard engineering". I suspect some of you have completed projects engineered in a like fashion. Most of the time things work out pretty well. I did get some suggestions from my friend Bill Cunningham, an engineer and co-inventer of the cool tower.

A good way to visualize the air flow is to compare air flow to water. Water is, of course, a much denser fluid than air, but the principle is the same. Tower height, or the distance from the bottom of the pads to the air outlet, will determine the velocity or pressure of the air. The greater this distance, the more air pressure created, similar to a water column. We are using a column of cool moist air (compared to the hot dry outside air) to create this pressure.

To determine tower width, or cross section, use the water analogy here, too. The larger the size of a pipe, the greater the volume passes through the pipe at a given pressure.

Enhancements will increase the air flow; upwind and downwind scoops are my choice. Other methods include rigid and movable cloth baffles. Barometric operated louvers also work to direct the air through the pads and create increased pressures.

Pad material choice for me is CEL-dek. At first I installed the expanded paper pads that are much less expensive. Even the old standby for coolers, aspen pads, will work. Water must flow down the pads and air must pass through the chosen medium. The CEL-dek pad works best because it has low resistance to air passing through it.

Duct work must be as large as possible. Having the air move through hallways and doors of the structure is best. An open floor plan works well. Cooling a large open area is much easier than cooling many rooms. If you use duct work with the cooling tower, the ducts must have a larger cross sectional area than ducts in a forced air system.

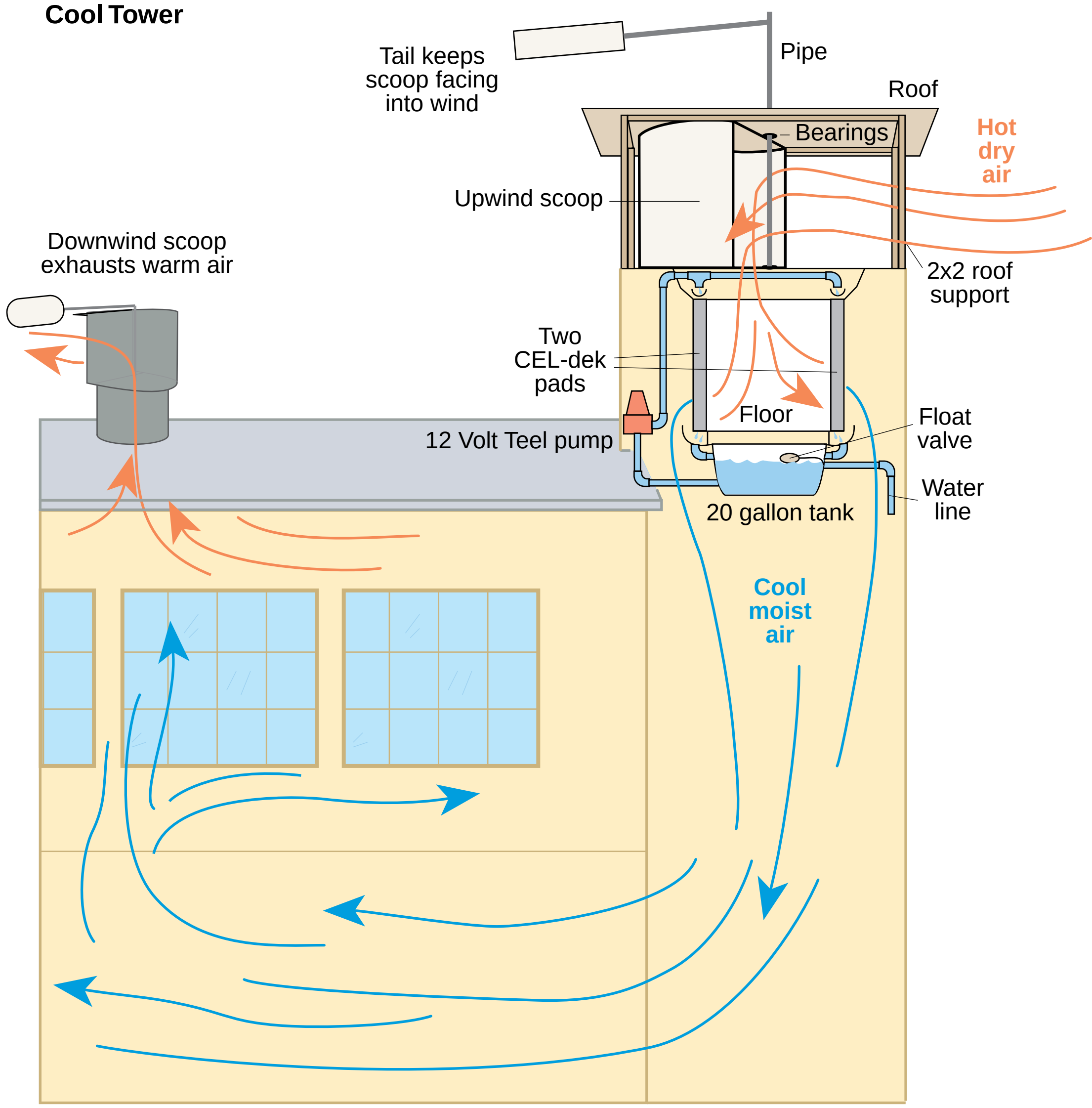
Vents must have a larger opening than those used with a forced air system such as conventional air conditioning or evaporative coolers. We are moving the air naturally with small pressure differences. Use large openings that don't restrict air movement.

What Kind of Water?

Evaporating water is what creates the cooling and makes evaporative coolers and cool towers work. Rainwater is the perfect source for the water used in cool towers because it does not have dissolved salts or minerals. Well water can contain dissolved minerals. As the water evaporates from the pads, whatever minerals it contains are left behind. This buildup will eventually clog the pads and block air flow.

We chose to get water for all our needs from the water harvesting systems we installed. Yes, we live in a desert, with an average annual rainfall of only 12 inches and we have plenty of water for all uses. The CEL-dek pads in our cool tower have had only rainwater on them since 1986. They have little mineral buildup on the surfaces.

Cool Tower



Normally you can expect to replace cooler pads every year, or at best every other year. I have seen cooler pads fed with ground water that have more buildup after less than one season than my eight year old pads fed with rainwater.

How Much Water

Approximately 1000 BTUs of cooling is created per one pound of water evaporated. On a hot summer day with low humidity you can expect to use 50–100 gallons of water. The most we have used in one day is about 60 gallons to cool the entire house. When we only cool parts of the house (“zone cooling”), we reduce this by 50–75%.

Other Benefits to a Cool Tower

Would you believe the cool tower helps heat our home in the winter? Our greenhouse has excess solar gain, so we open a small door in the cool tower leading to the greenhouse. The upwind scoop on the cool tower forces cool outside air into the greenhouse and excess heat is pushed downstairs. Cool air escapes through a vent located low in the downstairs room and is replaced by more warm fresh air from the greenhouse. We call this our fresh air heating system.

When we go away for an extended period of time in the summer, we open all the vents from the cool tower but leave the water pump off. With a slight breeze, fresh air flows through the house. This keeps the house from building excess heat.

Bill Cunningham built a cool tower on his office and shop/garage with south and east facing windows in the cool tower. They provide light and heat for both areas in the winter. In the summer they provide soft indirect light.

Conclusion

We started construction on the cool tower in the spring of 1985 and used it that summer. The system has undergone several changes. The first upwind scoop was metal, and not a good choice unless you use aluminum. Our scoop now has a framework of steel covered with heavy canvas. The cool tower has been in operation nine years. On a hot dry day (100°F with 10% humidity) the air coming from the tower is 65–70°F. We are very pleased with the performance. I am saving the finishing touches for a 110°F day — that's when working inside the cool tower is quite enjoyable!

Access

Author: Charles Van Meter, Alternative Research Center Inc., PO Box 383, Vail, AZ 85641-0383 • 602-647-7220

Custom Cool Tower & Solar Design, Bill Cunningham, 5085 S Melpomene Way, Tucson, AZ 85747 • 602-885-7925

Suppliers of CEL-dek: Munters Corporation, Mrs. Pat Thomas, Box 6428, Fort Myers, FL 33911 • 1-800-446-6868

12 Volt Teel bilge pump: Stock # 1P811, W.W. Grainger Inc., local phone book

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Above: Ed Rannberg with his electric Lightning Rod will attempt to break the new world land speed record sometime this year.

Speed & Utility

Michael Hackleman

It feels like Spring. In the transportation arena, things are popping up all over. Where do I begin?

Land Speed Record

Would you believe a new world land speed record for electric vehicles? It happened at Fort Stockton Test Center's 7.7 mile oval track on March 11, 1994. A GM Impact, with a thorough aerodynamic facelift and a run weight of 3250 pounds, travelled 183.075 miles per hour over one mile in the 1000 kilograms (2205 pounds) and above category. This sets both a national and international record for miles and kilometers for EVs. Good job, GM! The old record, set by Roger Hedlund at 175 mph remained unbroken for two decades.

Last year, EV pioneer Ed Rannberg (of Kawashaki fame) took a shot at the same land speed record in the Lightning Rod, a machine of his own design (see photo above). At season's end, the Bonneville salt flats were anything but flat. The bouncing was so severe, Ed pulled the plug at 150 mph.

I saw Ed at the Disney Clear Air Road Rally in Los Angeles the second weekend in April, and asked him about the impact of the new record on his plans. "It has lent a lot of credibility to my effort with sponsors," Ed replied. "We will have three speed windows in the year. We're geared to push the record over the 200 mph mark." Ed let me climb into the cockpit of the Lightning Rod. What a feeling! This is a very solid machine. The beautifully-crafted quarter-scale model proved the aerodynamics and stability in the windtunnel. Using only off-the-shelf components, the Lightning Rod's got the motors, batteries, and control scheme to do the job. Good luck, Ed!

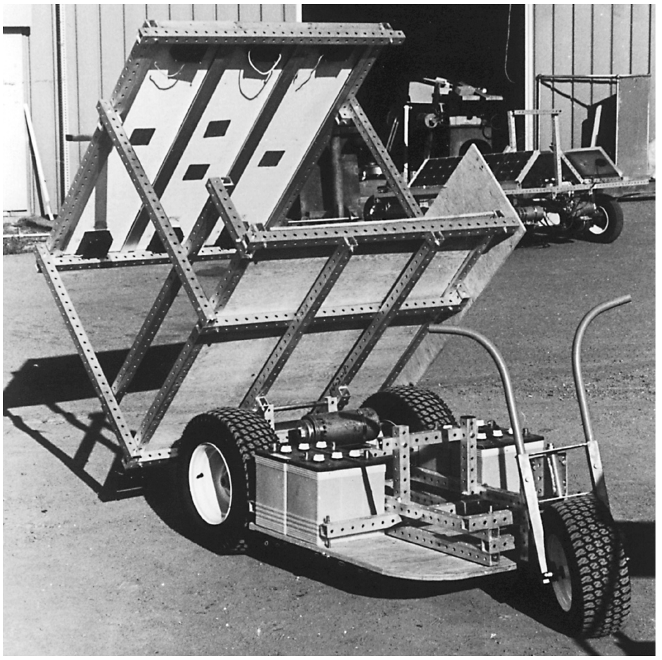
Box Beam Cometh

I'm pleased to see that Phil and Richard Jergensen (and support crew) are winding up the layout of a new book *Box Beam Sourcebook*. We obtained aluminum

box-beam for a junior high class project building an Electrathon class vehicle, and I'm glad we did. Our vehicle has gone through a half dozen evolutions with the same material. Richard sent me a shot of an EV trike (right) that Phil built years ago using box beam. Solid looking! The sourcebook will expand on ideas and applications (including wood as a material) and cover much more than vehicles (desks, shelves, and other furniture). A newsletter, *Box Beam Builder*, is also coming off their drawing board. Look for it soon.

New Book
I'm working on a trade book (with color!) for electric vehicles, that should be out before the end of the year. Tentative title is *Electric Vehicles: Designs for the Individual, Community, and Planet*. The book will detail 70 vehicles, ranges in treatment from electric-assist bicycles to ultralight rail, and is written for the layperson, designer, and industry.

Access
Michael Hackleman, PO Box 63, Ben Lomond, CA 95005



Above: An early Jergensen box beam production.

An Electric Mule

Michael Hackleman

On the Hilo side of the big island of Hawaii, more than 250 inches of rain fall each year. On a large sustainable organic farm, Harry MacDonald manages the production of Awapuhi for Paul Mitchell Systems (one ingredient in their hair products). On the hilly terrain, only one vehicle can haul compost and deliver machinery for maintenance without breaking up the fragile turf. An electric mule.

The mule is an electrified 2WD Kawasaki 500 Mule. Having worked on the Mana La project and a variety of electric utility vehicles, Harry was well aware of the potential of EVs in farm work. Harry also runs the Harley Davidson shops on the big island (in Hilo and Kona). When a Kawasaki Mule ended up at his store, Harry called in Tom Carpenter to assess its potential as an electric.

Tom Carpenter is no stranger to electric propulsion or offroad vehicles. With a background in marine electronics, he once maintained four electric boats, each a 24 foot bay launch owned and operated by residents in Newport Harbor. Also, Tom owns a 1952 Austin Champ, a 4WD British military vehicle built by Rolls Royce. With an estimated 40 Austin Champs remaining in service worldwide, maintaining his vehicle has been a challenge!

Standing alongside Harry in his shop, Tom sized up the Kawasaki Mule. “The first thing I noticed,” Tom explained, “was that, with the engine and infinite ratio transmission removed, there would be adequate space for batteries. The second thing I noticed was the flatbelt drive of a Harley Davidson Softail sitting next to the Mule. My experiences with the belt drives of the electric launches were good. They were reliable and quiet. The combination was clearly going to work.”

Above: Tom Carpenter rides the silent, non-polluting Mule down the beach.

The Conversion

With a thumbs up from Harry, Tom set to work. First, he contacted Ken Koch at KTA Services and ordered the parts he would need for the system the two of them designed. Next, he removed the engine, transmission, and engine-related components. Tom welded together a 3/8 inch aluminum motor mount, fashioned to bolt to the original engine mounting holes. When it arrived, the 6 hp series Advanced DC Motor (A89-4001) was bolted up. Since the locking differential of the Mule has an internal 6:1 ratio, Tom opted for a 1:1 ratio of the timing belt pulleys.

There was room for six batteries in the Mule, five in the rear and one under the single front seat. Would the batteries be 6 Volt or 12 Volt? Since the vehicle was intended for farm work, rather than recreational or street use, Tom opted for six 6 Volt deep-cycle batteries, or a pack voltage of 36 VDC

A Curtis 1205-201 controller, rated 36–48 Volt and 350 Amps, was purchased. The controller’s PV-6 pot box was connected through the existing throttle cable to the foot pedal. The locking differential allowed a mechanical Forward and Reverse, so no electrical reversing was required. A DC contactor (Albright SW-180B) was selected for key switch operation. The vehicle’s original 12 Volt auxiliary battery was replaced with an isolated DC-DC converter (Newmar 48-12-12I, 20–56 VDC input, 13 Amp peak output). A dual main

circuit breaker (GE, TQD150) was added to isolate the battery pack from the vehicle for servicing.

With a wet climate in mind, Tom installed the controller, contactor, pot box, meter shunts, and a 12 VDC fuse strip inside a plastic Carlon box. An outdoor timer box, mounted under the front seat, houses the circuit breaker within easy reach of the driver.

The Battery Pack

Tom selected sealed, absorbed-glass matte, deep cycle batteries for the Mule. Used in wheelchairs and other motive power applications, the Concorde 6 Volt batteries weigh 68 pounds each, are rated at 180 Amp-hrs (20 hour rate), and use lug terminals.

To support the five batteries, Tom fashioned an aluminum frame from 1 1/4 inch aluminum angle and pop riveted it together. The sixth battery of the pack is mounted on the metal floor just under the front seat.

Solar Charging

The Mule is strictly solar-charged. Originally, it was designed to recharge from one of the three solar energy stations located on the 67 acre Awapuhi farm. Each station is composed of a dual-axis tracked solar electric array (15 Solec S100s), a battery pack (24 VDC, 1400 Amp-hr capacity), and an inverter (4000 watt sine wave Trace 4024, 120vac). Tom, who has a solar installation business, designed and installed the stations. A K&W charger (120 vac input, 24 VDC output) was purchased to recharge the Mule's batteries. Once pressed into service, the Mule's role was suddenly expanded. An alternate charging system resulted.

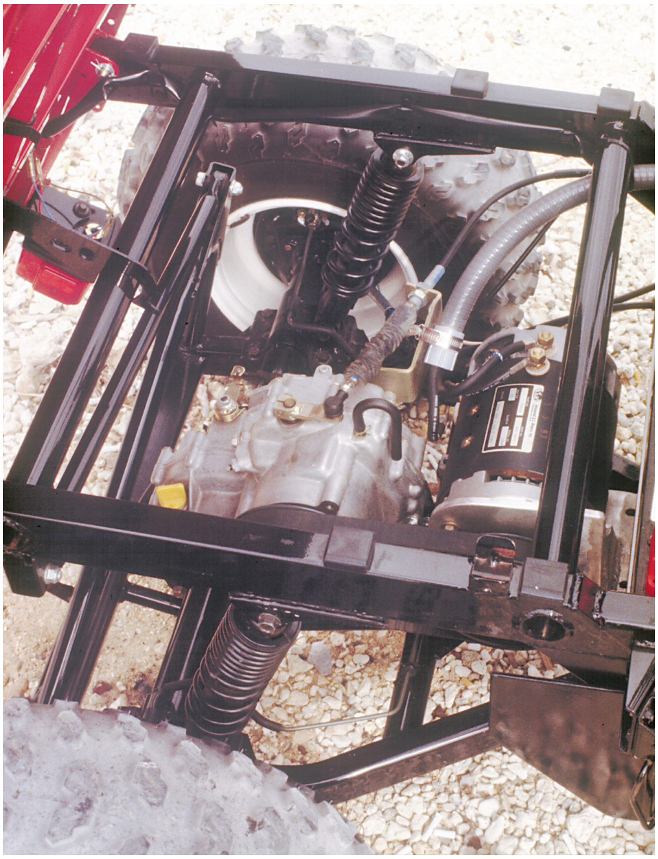
The Mule's Work Day

The Mule's steady work is hauling compost around the farm. The four foot square flatbed is designed for dumping, and tilting to drop its load. A drop-pin hitch secures a trailer that adds an additional 0.5 cubic yard of capacity.

"The electric Mule is the ideal vehicle for this hilly terrain," says MacDonald. "The road is dirt and loose gravel, but the turf is fragile and slick when wet. This job calls for strong torque without tire spin."

Occasionally, the mule does other work. One job is transporting the mowers and weedwackers to work areas. Another is hauling a 5000 watt generator to various work sites when power tools are needed. When a new building was planned, Tom had a different idea.

"I thought it would be interesting to use the Mule as a power source," he explained. "I attached a quick-release plug to a Trace inverter (36 VDC input, 120 vac output) to tie into the battery pack. This proved ample for powering the tools."



Above: There's plenty of room for the Mule's electric motor and drive train.

Since the Mule would be sitting all day at the building site, Tom decided to install three 100 Watt Solec panels on the Mule's roll bar assembly. In bright sun, the 6 Amp charge rate was just right, keeping the battery pack topped off despite the constant drain of power tools through the workday. "The silent ac power was an instant success with the work crews," Tom reported.

Sealed batteries are sensitive to overcharge. To limit the charge rate to a maximum of 2.2 Volts per cell, Tom added a charge controller, a Heliotrope CC-20, between the panels and battery.

"We've gotten into the habit of parking the Mule on any slope that tilts the panels toward the south," Tom explained. "That maximizes the charge rate. After four months of continuous operation, we have yet to plug the Mule into one of the solar stations."

Instrumentation

Several instruments were added to keep tabs on the Mule's new power plant. A dual-scale ammeter measures up to 500 Amps in propulsive power and 50 Amps for 12 Volt functions. A 0–50 VDC, sealed

Above: Michael tests the Mule's performance. With the battery pack located so low in the vehicle, this EV felt stable on the rock jetty at the beach.

military surplus meter lets the driver monitor either the 36 Volt or 12 Volt system.

"The instruments are useful during the learning curve," Tom said, "but I won't install them on my next prototype. I'd rather use something simpler, like an Ananda Smart Light." The Smart Light is a three-color display that, through steady or flashing lights at various set points, tells the battery's state of charge.

A cycle computer, a VELO, was added to watch vehicle speed, distance, and time. It also recorded the maximum speed and accumulated distance. The magnetic sensor was glued to the left rear wheel, the magnetic pickup was secured to a brake line, and the computer was calibrated to the tire's circumference.

The First Run

How was the first trial run? "I charged up the batteries and selected a gravel road with rolling hills," Tom said. "I went 35 miles before I got low. The average speed was 13.8 mph. My highest speed was 27 mph. That was definitely downhill."

After a recharge, Tom added two additional 6 Volt batteries, strapping them down to the rear bed. With the pack at 48 VDC, Tom tried again. "The batteries went flat at 35 miles again, but the average speed went up to 17 mph."

The Bottom Line

What did it all cost? Battery pack: $600. A basic conversion kit: $2,160. The DC-DC converter: $190. Miscellaneous hardware and aluminum angle: $250. Tom estimates that it took him 30 hours to convert the mule. "A duplicate," Tom said, "would take only 20 hours."

What's Next?

Tom is tempted at this point to build a 4WD offroad vehicle from scratch. I have talked with him about teaming up to build something for use at Home Power's homestead. We've identified some of the component subassemblies and this design is still in the works. What if it were another conversion? "A 4WD Kawasaki Model 1000 would be my first choice," Tom replied. "These are solid machines. They're tough enough to handle the electric motor's low end torque. I'd push the pack voltage to 72 Volt, too."

Access

Author: Michael Hackleman, PO Box 63, Ben Lomond, CA 95005

Tom Carpenter, HCR 5201, Keaau, HI 96749

AAA SOLAR
camera ready
run this ad sideways like this type
9.9 inches wide
7.5 iches high
black and white

this is page 49

Above: Clark Beaseley's Electrathon racer, Slingslot has a facelift! The new sleek body design is hot out of a mold that will be used to make others for sale.

Electrathon Racing in Michigan

Jeffrey F. Dailey

The West coast is the undisputed hotbed of Electrathon racing in the USA, through the efforts of Electrathon America, Clean Air Revival, and other groups. Soon that distinction will be challenged by a new kid on the block: the EVT.

EVT is short for the Electric Vehicle Technology program at Jordan College Energy Institute (JEI) in Michigan. After working with events such as the 1990 GM Sunrayce (Florida to Michigan) and the Ford Hybrid Electric Vehicle Challenge, JEI formed the 1994 Michigan High School Electrathon competition. A year after its conception, most of the 23 participating high schools scattered throughout Michigan have working vehicles that they are refining for the racing debut on June 11, 1994.

The Project Begins

In the spring of 1993, JEI drafted a letter announcing the competition and mailed it to all Michigan high schools. Twenty-nine schools responded to the challenge and were sent Electrathon America rules.

In October 1993, the registrants converged for a workshop. JEI personnel or outside consultants conducted presentations on organization, safety, construction, fundraising, and materials sources. The teams also received some instruction on writing the mandatory progress reports. Car numbers were assigned and three JEI representatives were designated for each team to shepherd them through any difficulties. Each team was well aware that the next time they would all meet was in competition.

A hotline was set up for voice and FAX. Since academics were a part of the competition, progress reports were required. One incentive to excel in the reports is grading (scoring) them. These scores will be used to establish the starting positions for the race. The reports also remind schools that time is fleeting.

JEI has sent out several newsletters to announce race-related facts and serve as further encouragement to teams. These also answer frequently-asked questions from the hotline, and advice that seems to be in order. All questions are treated as confidential. Any specific question that might reveal a technique or strategy is not publicized without permission of the originators.

Since JEI has no previous Electrathon experience to draw upon, it purchased a race car from Clark Beaseley. Consumer's Power, a large Michigan utility, purchased this vehicle and donated it to the school to help with publicity. The car's main benefit, though, has been the excitement generated when brought to high schools and displayed at student assemblies.

An enterprise of this magnitude has generated many challenges. Financial sponsorship is slowly growing. The workload on student, faculty, and staff at JEI has been taxed. More help from outside the college would be appreciated. (Ed: *HP* readers, take note. A helping hand, a donation, or sponsorship are ways *you* can become a part of history.)

The Upcoming Race Day
A track outside of Grand Rapids will host the Electrathon event on June 11th. The vehicles will compete on a half mile paved and banked oval track, under the watchful eye of Clark Beaseley. The site has seating capacity for 10,000 people and a fairgrounds to attract vendors and displays, and room for inspections and repairs. The Electrathon will run a daytime event on the same date as a nighttime stock car race, so that the track's single event insurance will cover both. Since spectators must traverse a large area between the parking lot and bleachers, owners of electric cars and trucks will be invited to display their vehicles to the general public in this area. Immediately prior to the Electrathon event, the display vehicles will form a parade for a turn around the track.

In the traditional style of Electrathon racing, the race will be one hour long, with laps counted, and the vehicles with the greatest distances declared the winners. All prize monies are awarded to the schools' scholarship funds, with $5000 for first place, $3000 for second, and $2000 for third.

About Jordan Institute
The Associate Degree in Electric Vehicle Technology (EVT) program at JEI resulted from the college's commitment to using renewable energy to keep our planet habitable. Other programs emphasize the use of solar energy for heating, PV, wind, hydro, and biomass. The program teaches the maintenance of the millions of EVs already in use. This is a two year program for a beginning student. Students with a year of college may complete the EVT program in one year.

The course work in the EVT program ties in with other programs by being as generic as possible. Basic Electricity and Controls classes are in demand for most students. Other popular classes are Motors and

Below: Dan Parks show off his old and new composite Electrathon bodies. With the world record at a bit more than 35 miles in one hour, competitive vehicles must be very slippery as they move through the air.

Generators, Inverters and Battery Chargers, and Energy Storage.

There are seven Jordan College campuses throughout Michigan, currently in candidacy status for North Central Accreditation. JEI is the only campus to offer energy-related courses, and confer baccalaureate degrees. Typical enrollment is 100–130 students. Each student gets individual attention due to the small student-to-teacher ratio.

Electrathon is only one of many programs Jordan College would like to sponsor. Plans are already underway for a 1995 competition! All Michigan High Schools are encouraged to arrange to compete with high schools in neighboring areas, or to travel outside the state to other events across the country.

Access

Jeff Dailey, 17206 SR 1, Spencerville, IN 46788 • 219-627-6222

Jordan Energy Institute, 155 Seven Mile Road, Comstock Park, MI 49321 • 800-968-3955

Good Books

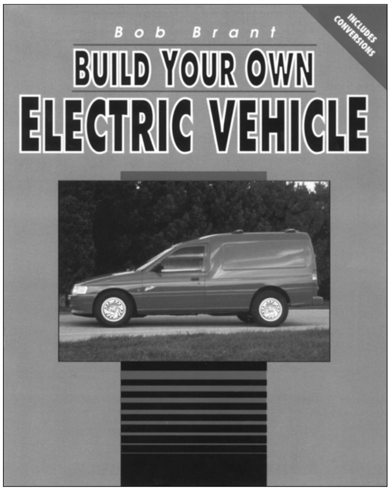
Build Your Own Electric Vehicle

Written by Bob Brant

Reviewed by Michael Hackleman

Get this book! Electric propulsion is shaking up the automakers and the petroleum industries worldwide. As industry, entrepreneurs, and general public realize that electric vehicles (EVs) are here to stay, the more important it is for everyone to know the basics (and virtues) of EV propulsion, its current state of development, and what's coming down the pipeline. Bob Brant, with his aerospace and industry background, has done a good job of painting this picture. Bob wasn't shy about visiting many long time EV builders and owners. Merging their experiences with his own only strengthens the robustness of the book and the emerging EV industry.

In Bob's own words, "My involvement in electric vehicles stems from (college) days....(my) graduating engineering class built a self-propelled electric robot....every EV breakthrough that's happened from that time...has only made me more fascinated with the concept, more convinced of its substantial personal and environmental benefits, and more curious why stronger steps have not been taken to make EVs a reality."



It's all here. EV history. Ac and DC motors. Controllers. Batteries. Chargers. Sources. Clubs and associations. Choosing a chassis and designing the layout for your application. The book focuses on the design of conversions of cars and trucks. The technical strength of the book can be intimidating to the layperson, but it's easy to leapfrog through the running text and maintain the continuity. This book complements Mike Brown's *Convert It*, and the serious converter will want both.

Access

Build Your Own Electric Vehicle is seven inches by nine inches, 310 pages long, ISBN is #0-8306-4231-5. It is available from TAB Books, Blue Ridge Summit, PA 17294-0850. Cost is $16.95.

Electric Vehicle Options: Power & Climate Control

Shari Prange

Once you look beyond the required parts of an electric car — motor, controller, batteries, and charger — there are a few options. These options — power brakes, power steering, heating, and air conditioning — can be more or less important, depending on the car you want to convert and the conditions under which you will use it.

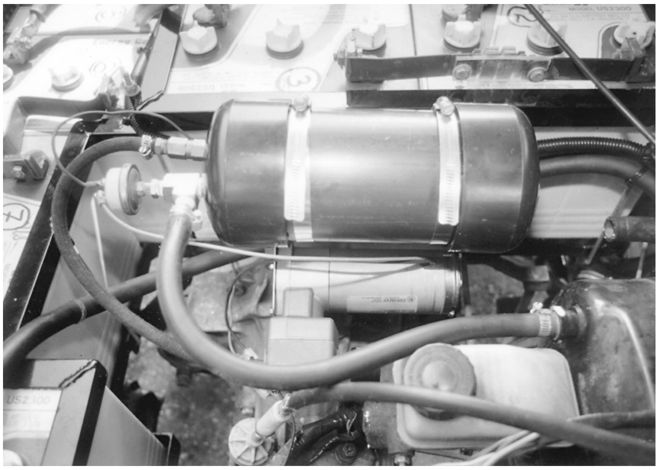
Power

We're not talking about muscle cars here, nor do we refer to status cars. We're talking about the amenities that differentiate a basic model car from a more costly model: power windows, power brakes, and power steering. You won't see most of these options on EV conversions. They are found primarily on "luxury" models. Luxury models tend to be heavy, full of sound-deadening material, not designed for efficient fuel use, and they frequently have automatic transmissions. They are not prime candidates for conversion to electricity. However, let's discuss some of these options.

Power Brakes

This is the option you are most likely to find, even on economy cars. Fortunately, it is also the one that is easiest to accommodate, and is actually desirable in an electric vehicle.

Over the past few years, almost all models of cars have gone to front disc brakes. Disc brakes can dissipate heat better than drums, and so are less prone to "fading". However, they require more pedal pressure in use. Hence, power assisted brakes.



Above: A vacuum pump, reservoir, and switch provides power brakes in a VW Rabbit.
Photo by Shari Prange

Power brakes normally draw their "power" from vacuum created in the engine manifold and connected to the brake system by a hose. In an electric conversion, there is no manifold, so you must provide another source of vacuum.

This is easily done with an electric vacuum pump that runs off the auxiliary battery. The pump is used in conjunction with a reservoir, and is activated by a switch and relay. When the air pressure rises to a certain point inside the reservoir, the switch causes the relay to close, which turns on the pump. In a few seconds, there is vacuum inside the reservoir again, and the pump turns off. Using the reservoir gives the driver several applications of the brakes before the pump needs to come on.

If your donor car has power brakes originally, by all means keep them in the conversion. The conversion, being heavier than the original car, needs all the brakes it can get.

Power Steering

Power steering isn't really necessary on most cars of a size suitable for conversion. However, a few of the older models, and a large number of the newer ones have it anyway.

If possible, avoid power steering. It eats up energy unnecessarily that would be better put into moving the car down the road. If your donor car has power steering, see if there is another version of the same or similar model without it. You may be able to bolt in a manual steering rack from the junkyard. (And you may get it for free if you give the junkyard your power steering rack.)

If you have to have power steering for some reason, run it off a second shaft on the non-drive end of the motor, or use a separate small motor running off the battery pack. Neither way is ideal, since it uses some of your drive energy, and adds one more component taking up room under the hood and one more place for a potential problem.

Power Accessories

If you want to impress your friends, you can leave in the power windows, power mirrors, and power radio antenna. They run off of your 12 volt auxiliary battery and don't use enough power or weigh enough to make a difference. Enjoy!

The final ubiquitous "accessory" is the cellular phone. Cellular phones work just fine in electric cars. (I have this on the authority of a customer. I won't have one of the darn things. My car is the last safe haven where I can get away from the phone!)

Heat

In many parts of the country, passenger compartment heat is essential. There are three ways to accommodate this that are commercially available.

The oldest method involves a small heater that actually burns some type of fuel. These were common in the days when air-cooled cars were common, and had notoriously poor heaters. These heaters are still available in places that supply VW modification parts.

This type of heater is effective, but violates the original reason for the electric conversion: elimination of combustion. In some states, it may also disqualify the car from tax incentives, since the car is no longer a "pure" electric.

A second type of heater is a resistance grid air heater. This runs off the main battery pack and heats a wire coil, just like a household electric space heater. This type of heater can be used with good results, especially if it is mounted in the original blower system.

A third type of heater uses electricity from the main battery pack to heat water, which is then circulated through the car's original heater core. The heat is dispersed through the original ventilation system.

This is more effective than the air heater, for the same reason that water-cooled cars have better heaters than air-cooled cars. It is more efficient to transfer heat from the heating element to water, which is more dense, than to air.

None of these heaters will give you the sauna-like luxury available in a gas car, but they will make the car comfortable to use, even in very cold weather.

Both the air and water heaters will decrease the car's range, since they draw power from the main battery pack. How much range is lost will depend, of course, on your driving and weather conditions, but 10–15% seems to be typical.

If possible, in very cold weather, store the car in a heated garage, so that it's already warm when you get into it, and any heater you use won't have to work as hard.

Air Conditioning

The other climate aspect that is a survival issue in some parts of the country is air conditioning. Historically, this has not really been practical in an electric car. Conventional air conditioning systems use a lot of horsepower — almost as much as it takes to move the car down the road. This is why gas cars get such terrible gas mileage when the air conditioner is turned on full blast.

Attempts have been made to run conventional air conditioning systems from an auxiliary shaft on the motor, or from a second motor, but these have not really been satisfactory. The performance of both the car and the air conditioning systems in these arrangements are anemic.

Some people have used a blower fan without any cooling system. This isn't really air conditioning, but at least it moves the warm air around and gives you the illusion that you're cooler.

A somewhat better idea is the small solar window fan. This unit fits between the window and the top of the door frame. It is powered by a tiny solar panel, and it sucks the hot air out of the car and replaces it with fresh air. This is very useful on a car that will be left parked in the sun for hours.

Help, however, is on the horizon. The air conditioning technology is in a state of transition, due to the need to eliminate the traditional but ozone depleting CFCs. The new air conditioning technology that is emerging for gas cars is much more compact and efficient, and should adapt well to electric cars.

Breaking Out of the Mold

Electric cars have been stereotyped as limited in their abilities and in the kinds of climates in which they will work. The reality is that there are satisfied electric car owners in the broiling sun of the South, in the icy winters of the Yukon, and in the steep and twisty mountains of the Pacific Coast.

Access

Shari Prange, Electro Automotive, PO Box 1113,
Felton, CA 95018 • 408-429-1989

Site Analysis for Wind Generators

Part 2: Your Site

Mick Sagrillo

In our last episode (HP#40), we outlined some ways of estimating the wind resource in your area. We also developed a method to determine the average wind speed at hub height for your proposed wind generator. The question before us now is: where on your property is the best place to put your wind generator tower?

The answer to this one is easy. Put the tower where it's windiest! It is actually windier in some places on your property than on others. In this article, we will show you how to analyze your specific location so that you can maximize your wind resource.

Tools

The purpose of examining any potential renewable energy (RE) site is to optimize the RE resource, and therefore, the power output of the proposed RE generator. To accomplish this, you will need to gather some information about your site, such as:

- Location of vegetation and buildings
- Prevailing wind direction/directions
- System voltage (battery charging systems only)
- Surface roughness or topography.

From this information, we will develop a series of rules or guidelines that will help you qualify the resource at your site.

Vegetation and Buildings

Since any site analysis requires a specific location, we'll use our homestead as an example. Figure 1 illustrates the layout of the buildings and most trees on our property. Also noted are the compass points, and a distance scale. The numbers indicate the approximate heights of the trees and buildings.

The terrain in our area is somewhat rolling and relatively open, but spotted with buildings, overgrown fencerows, groves of trees, and the occasional woodlot (several hundred acres). While we live in farm country with some forested areas, this site need not be rural, strictly speaking. It could very well be a small town, suburban development area, or the edge of a larger city.

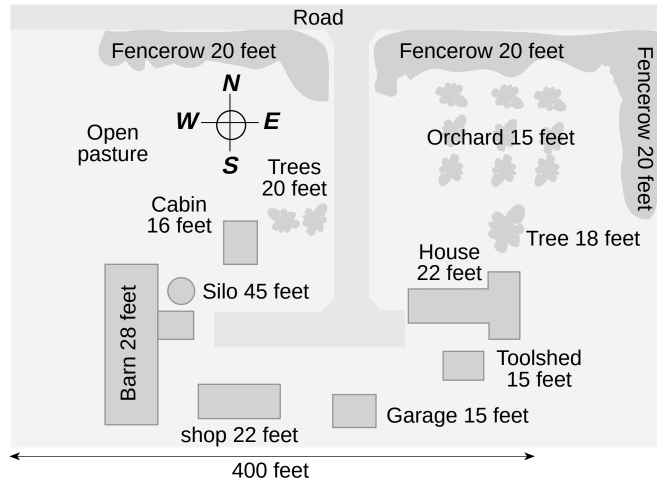


Figure 1

Tower Height

Remember from "Tower Economics 101" (*HP*#37) that our arch enemy is turbulence. It robs us of our fuel, the wind, and puts unnecessary wear and tear on the wind generator. Therefore, rule #1 is: minimize turbulence as much as possible. We'll return to turbulence later.

Another important consideration is that the wind generator must be at least 30 feet above anything within 500 feet — a *minimum* requirement. Let's call this rule #2. For anything larger than about 1 kiloWatt (kW), the "30 foot" above rule must include the blades as well.

As an example, let's assume that we will install a large wind system, say a high voltage 10 kW wind generator with a 24 foot rotor diameter. If we add the radius of the rotor (12 feet) to the 45 foot silo and the "30 foot above rule", we find that the minimum tower height for this location is 87 feet. Since an 87 foot tower is not readily available, we'll opt for the next closest size, 90 feet. Notice that we went up in height rather than skimp with an 80 foot tower. This is the minimum tower height for this location given a 10 kW wind generator.

We have the wind generator, system voltage, and tower height selected. Our next question is where do we put it to best utilize our wind resource.

Prevailing Winds

To answer this question, we need to know the seasonal wind patterns for this proposed site. This should be fairly obvious for your location if you have lived there for a least a year. If you are new to the area, ask your neighbors.

At our place, the wind blows quite regularly during the fall, winter, and spring. Summer winds are restricted to frequent thunderstorms. While brief, these storms are usually accompanied by high winds for several hours.

Winter is dominated by winds out of the north and northwest. Fall and spring bring winds from the south and southwest. While the winds from a summer storm come from any direction, they arise most frequently out of the west. We can see a pattern developing here (Figure 2).

The best place for the tower which optimizes our prevailing wind directions is west of the barn. We now have rule #3: after you determine the direction of the prevailing winds, site the wind generator upwind of any buildings or trees.

But Mick, you say, the wind sometimes blows from the northeast, east, and southeast. At those times, the tower and generator are downwind of the trees and buildings and in the zone of turbulence. Won't we have problems when the winds are from these directions?

Unless we install a movable tower (something no one has perfected yet), the answer is yes. Because the wind blows from any compass direction some of the time, we have to compromise. Since we are interested in where the wind blows most of the time, we have to accept that occasionally the tower is in a less than ideal location. This brings us to rule #4: in a site analysis, tower placement minimizes those compromised locations, thereby maximizing our wind resource.

Wire Restrictions
Since we know the rotor size and building height, we can easily determine the minimum tower height at this location. The distance of the wind generator to its controller is of little concern because it is a high voltage system. We can locate the tower almost anywhere on the property without worrying too much about wire size.

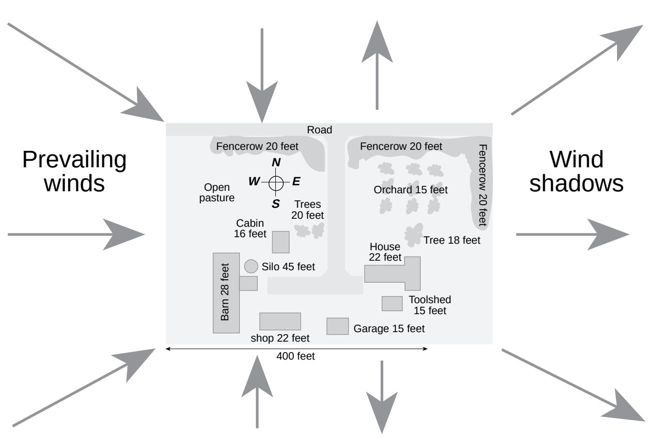


Figure 2

In a wind system, your wire run includes the distance from the tower to the controller plus the tower height, and back again. Because wire runs in a wind system can add up fast, higher voltage systems are preferable. Why is this, you ask. The power that a wind generator produces is a function of volts multiplied by amps. Thus, voltage and current are inversely related. If the voltage doubles, the current carried by your wires is cut in half, for a given amount of power.

The power lost in a wire run is a function of the wire's resistance (a function of the length and diameter) multiplied by the square of the amps that the wire carries. For a given wire gauge, doubling the voltage means that the wind generator can be located four times the distance and still have the same power loss! With wind generators, higher system voltages are easier to work with and more cost effective than lower system voltages. Which brings us to rule #5: raising system voltage gives you considerable flexibility in where you can put the tower.

Low Voltage Dilemma
Now, let's muddy the waters by lowering the voltage. Rule #3 would favor the location west of the barn. A tower near the house would be downwind of buildings and trees. It would see a lot of turbulence and reduce our power output. "Tower Economics 103" (*HP*#39) diagrammed the zone of turbulence behind such obstructions.

But let's suppose that we already have a low voltage system in the house, and upgrading to a higher voltage is not an option. The distance from the proposed tower site west of the barn to the house is 400 feet. Add the 90 foot tower height, and we have a low voltage dilemma. We cannot run 12 Volts for nearly 500 feet. Now what do we do, Mick?

We can opt to move the tower closer to the house. If we place the tower within 30 or so feet of the house, we reduce the wire run to under 150 feet. This will require some gonzo wiring, but is acceptable cost-wise. But now the only place for the tower is downwind of the buildings, which puts us into a zone of turbulence (see Figure 2).

Installing a wind generator tower is not like plopping PVs on the ground somewhere. It is a considerable project, involving concrete. We want to get it right the first time (concrete is not very forgiving). Therefore we must determine the extent of the turbulent zone at our proposed tower site.

Mr Wizard!
Now comes the fun! You will need a "giant weather balloon", the kind available from scientific mail order

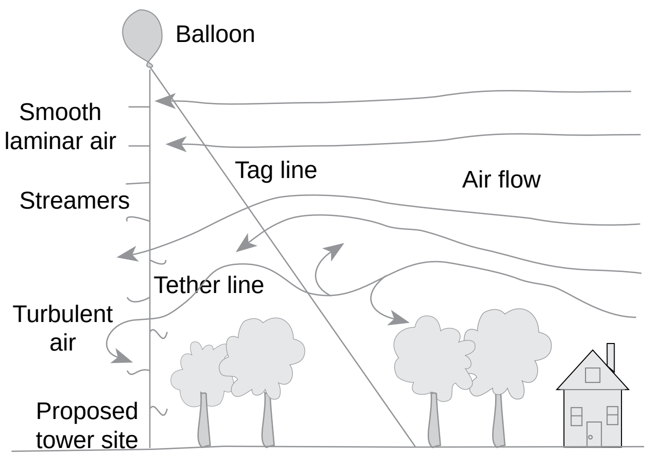


Figure 3
Adapted from *Wind Power for the Homeowner* by Don Marier

stores. (Admit it; you always wanted one of these as a kid. Now, you have an excuse to buy one!) Take it down to your local FTD florist, the folks who sell helium filled anniversary and birthday balloons. Have them fill it with helium. You might want to do this outside. Few florists have enough room (especially florists specializing in cacti) or doors wide enough to accommodate six foot weather balloons.

Once you get the damn thing home in one piece, it's time to conduct our experiment. Whatever you do, don't let the balloon go or it's back to the florist. Get someone to help (Mr. Wizard always has an assistant) rather than attempt this alone. Tie the balloon to a nylon cord about 100–120 feet long. This is your tether line. The other end of this cord should be securely fastened to a stake driven into the ground. Place the stake where you want the tower to be. Tie a second nylon cord, about 200 feet long, to the balloon. This is your tag line.

As your helper lets out the tether line with the balloon, tie streamers made of four feet long pieces of yarn or crepe paper every ten feet along this line. Keep the tag line from getting tangled up in the tether line and streamers. Tie the tag line off in the upwind direction once the balloon is in the air. Get the balloon to fly directly over your proposed wind site, as in Figure 3.

Why, you ask, are we doing all of this? Elementary, my friend. We are trying to determine the boundary layer where turbulence ends and smooth flowing laminar air begins. The streamers in the turbulent zone will ruffle in the wind, whipping around in all directions. Once you cross the boundary layer and reach the undisturbed air, the streamers straighten out and only blow downwind of the tag line. Count off the streamers to determine the height of the smooth flowing air. This is the minimum height for your wind generator tower.

Do this experiment over a period of days, with winds coming from different directions and at various speeds. This way you will have a good sample for determining the turbulent zone around the proposed wind site. You'll need to relocate the tag line from day to day as the wind shifts directions. When not in use, bring the weather balloon down so that a shifting wind does not blow it into a balloon-eating tree. If you live in a town or populated area, this technique is especially good to use to qualify your wind resource. By the way, this experiment is sure to bring every kid in the neighborhood to your yard.

You may discover that the boundary layer raises in height at higher wind speeds or when the wind comes over a building from a particular direction. Since you want to stay clear of the turbulent winds, you will need to determine the upper limits of the boundary for most wind conditions.

If you actually do the above exercise, you will empirically discover rule #6: rougher surfaces produce gustier winds, especially at higher wind speeds. The solution? It's rule #7: if you must be downwind of obstructions, raise your tower height to get out of the turbulent zone and into the laminar flow of air. Don't forget that the blades need to be completely above the boundary layer as well.

Estimating Heights

Let's assume that we are upwind of all obstructions again. We know that we still need to get the wind generator 30 feet above the downwind obstructions. But we don't know how tall the neighboring buildings and trees are. How can you determine their heights without risking your neck with a tape measure in hand?

One way is what I call the "shadow method". Suppose we want to know how tall our barn is. On a sunny day, drive a stake into the ground and measure the height of the stake above ground. Let's say it's four feet tall. Then measure its shadow. Let's say that the shadow

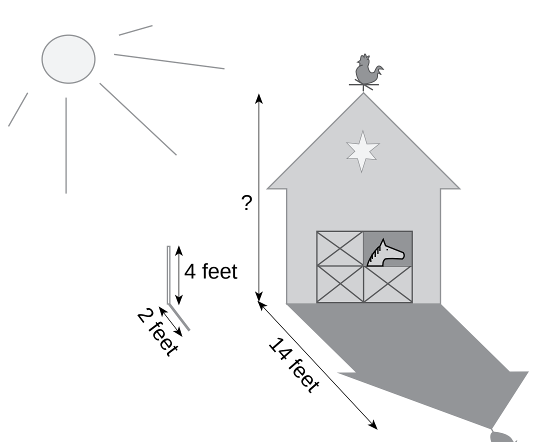


Figure 4

extends two feet. Next, measure the shadow that is cast by the barn. Let's say it's 14 feet. (See Figure 4)

Using the formula, we can determine the height of the barn without climbing.

$$\frac{\text{Stake height}}{\text{Stake shadow length}} \times \text{Barn shadow length} = \text{Barn height}$$

$$\frac{4 \text{ feet}}{2 \text{ feet}} \times 14 \text{ feet} = 28 \text{ feet}$$

Piece of cake! The barn is 28 feet tall.

But what happens if the sun doesn't shine in your area? Another way of determining heights is called the triangulation method (see Figure 5 below).

Let's say that we need to know the height of a nearby tree. With a 12 inch ruler in hand, stand far enough away from the tree so that when you hold the ruler in your outstretched hand and site past it to the tree, the tree is slightly smaller than the ruler. With ruler still in hand, record the height of the tree in inches (distance A, say, 10 inches). Then measure the distance in inches between the ruler and your eye (distance B, say, 30 inches). Finally, measure the distance, in feet, between the place where you were standing and the tree (distance C, say 180 feet). Now use the following formula to determine the height of the tree (distance D).

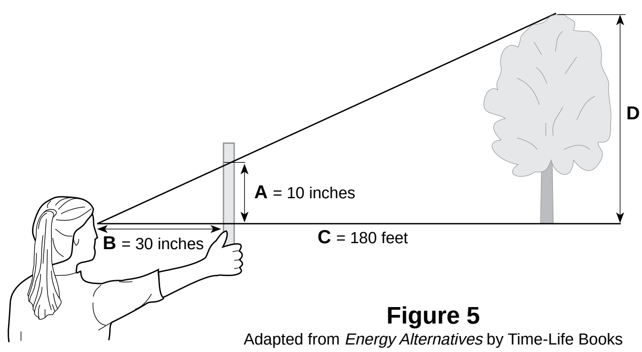


Figure 5
Adapted from *Energy Alternatives* by Time-Life Books

$$D = C \times \frac{A}{B} \quad \text{or} \quad D = 180 \text{ feet} \times \frac{10 \text{ inches}}{30 \text{ inches}} = 60 \text{ feet}$$

Simply and safely, our tree is 60 feet tall!

Trees, Trees, Trees

Let's assume that we have not just one tree, but an entire forest of trees. We have done the above exercises, and we know that the forest canopy is about 60 feet tall. Is a wind generator still practical?

Sure, but we need to get the generator at least 30 feet above the top of the tree line. In this case, we need to know the approximate age of the trees, their species, and the height that these particular types of trees will reach at this location. Why? Because of rule #8: trees grow, towers don't!

If the forest is made up of maples and ash, and the canopy is 60 feet high, you can be fairly confident that these trees are mature and will not grow much taller. You would be safe with a 90–100 foot tower. If the 60 footers are Douglas fir trees and you install a 90 foot tower, you can be assured that in not too many years the wind generator will be engulfed by branches. In most areas, Doug fir will be more than 90 feet tall. Your time and investment will have been wasted.

And More Trees!

Let's complicate the situation a little. Assume that you own ten acres of cleared land in a national forest made up of oaks or aspen trees. Either species will mature at around 40 feet in your area. Your house is only 18 feet tall and situated smack dab in the middle of the ten acres. That puts you at least 500 feet away from the trees. Since you are 500 feet away from the nearest obstacle except the house, you can get by with a 48 foot tower. Right?

Not in this case. While it may seem that you are an adequate distance away from the trees, you are essentially in a sheltered hole! The tree canopy is the effective ground level as far as the wind is concerned. A 48 foot tower at this location would be analogous to an eight foot tower on open ground.

The minimum tower height in this instance would be 70 feet (40 foot trees plus the "30 foot rule"). If you wanted to install a 1 kW wind generator with a ten foot rotor, a safer bet would be to include the radius of the rotor (or length of a blade) at five feet, to this height. This would put the tower height at 75 feet. Since there are no other obstacles above the forest canopy, prevailing wind direction is of little concern to us.

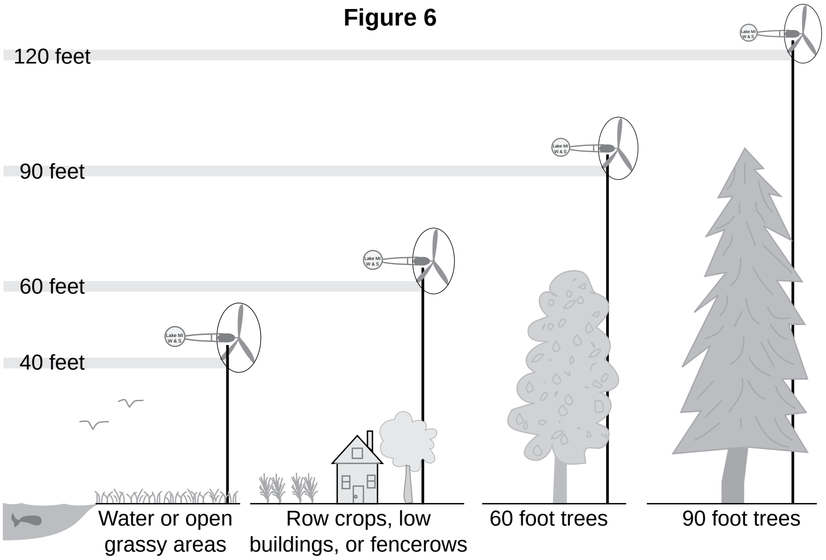
One final note about trees: avoid putting towers amidst a dense group of trees. It complicates the installation and jeopardizes the safety of the installer or service people climbing the tower. You don't want tree branches rubbing on the tower. It's not safe for the tower or the trees.

To Tree or Not to Tree

Folks who live around tall trees may feel discriminated against when it comes to tower height. They're right. But that's the price one pays for living in a tall neighborhood. Figure 6 graphically represents what I am talking about.

If we assume a given location with a given wind speed at any point in time, Figure 6 depicts how tall your tower must be at a minimum to compensate for the surrounding vegetation. Does this mean that you should cut down all of your trees? Hardly! Just ask anybody in Kansas about the value of shade. Does this

Figure 6



mean that a wind system in an area with tall trees is impractical? Not at all. No matter where you live, you still have to install the wind generator on a tower. So what we are discussing is the incremental cost increase of an additional 30 feet of tower compared to the cost of the entire system. ("Tower Economics 102" in *HP*#38 discusses this subject in detail.)

Low Voltage Options

Since many *Home Power* readers already have low voltage systems, and a goodly number also probably live near tall trees, let's revisit this issue.

Going back to rule #5, I recommend increasing system voltage first. Resistance to change aside, this will always be the cheapest option. In addition, systems need not be restricted in total power output. A 12 Volt system, for example, is limited to a power output from a few hundred watts to about 1.5 kW. Due to the amount of current that must be generated, building 12 Volt wind equipment larger than this capacity is just not practical. Because of this, 12 Volt systems larger than 1.5 kW are not even commercially available.

There are, however, a few tricks that are available to low voltage system users facing extremely long wire runs. Many of the newer wind generators utilize permanent magnet alternators. These alternator's produce something called three phase wild ac, which is rectified to DC with diodes in the system's controller before travelling to the battery bank. A three phase wind system utilizes three wires to transmit current down the tower to the controller. A DC system only uses two wires, positive and negative.

The advantage of three phase ac is that the current produced by the alternator is split up and transported equally by its three wires. By contrast, all the current produced by a DC generator is transported down a single wire. Three phase alternators can use lighter gauge wire for a given wind generator capacity at a given distance. Therefore, three phase permanent magnet wind generators offer greater flexibility in siting — they allow longer distances from the battery.

High Voltage Transmission

One final trick that can be used for low voltage systems is to actually install a high voltage wind generator, but then step the voltage down at the batteries. With a three phase ac alternator, the solution is simple: use a three phase step-down transformer before the rectifiers. These transformers are relatively inexpensive when compared to cost of enormous wires.

Transformers are only about 85% efficient, so some power is lost in the process. The efficiency can be boosted somewhat by adding capacitors to the system. While a 15% loss of efficiency may be considered extreme by some, it is a small price to pay when the option is a much-compromised tower location tethered to welding cable-sized wires.

There is no such thing as a DC transformer for systems utilizing a DC wind generator. However, a linear current booster (LCB) performs essentially the same function as an ac step-down transformer. An LCB is a high speed switching device that will allow the user to transmit high voltage DC, reducing the voltage at the battery bank. LCBs are also about 85% efficient. They are, however, more expensive than transformers.

While neither the transformer nor the LCB is a cheap option, they do allow the user to cut down on the size wire needed. In many cases, these devices more than pay for themselves in money and aggravation when compared to the cost of heavy-duty wires. But their big advantage is that they allow the user to site their wind system at the most ideal location rather than compromise with less than ideal tower placement. We have customers using these devices that have sited their wind generators as far as 2000 feet from their battery bank.

Sounds of Silence Broken

You may be thinking, why not virtually eliminate the wire run by just mounting the tower right on top of their house. Don't even consider this idea for several reasons. First of all, few roofs have the structural beefiness to support the loads presented by a wind generator and tower, let alone when the wind is trying to blow them over.

Second, even if your roof was strong enough or the tower was short enough or the generator was light enough, there is another serious drawback to this idea. Any rotating electrical generating device produce a harmonic that we can perceive by touch as a vibration. That harmonic vibration is transmitted down the tower. Touch one sometime and you will feel what I mean.

If the tower were attached anywhere to a building, the building itself would begin to resonate, similar to a guitar's sounding box. This resonance would vibrate the building, doing who knows what kind of structural damage over time. In addition, the resonance would develop into sound inside the building. Unless you are deaf and don't mind things walking off horizontal surfaces or jumping off walls whenever the wind is blowing, this is a pretty bad idea.

Recap

Proper siting of a wind generator tower is actually easier than initially meets the eye, if you remember the following guidelines:

1. Minimize turbulence.
2. Install the tower at least 30 feet above anything within 500 feet.
3. Note your prevailing winds and stay upwind of any obstacles.
4. Minimize compromises in location, voltage, and tower height.
5. Consider higher voltages.
6. Rougher surfaces produce gustier winds.
7. If downwind of obstacles, compensate with a taller tower.
8. Trees grow, tower don't.
9. Never attach the tower to your house.

You now have the tools to properly site your wind generator. Take the time to ask questions and do it right. You will be rewarded with a system that takes the best advantage of one of Nature's greatest and most powerful gifts: the wind.

Access

Mick Sagrillo flies his balloons at Lake Michigan Wind & Sun, E 3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

Giant weather balloons:
American Scientific and Surplus, 3605 Howard St., Skokie, IL 60076 • 708-982-0870

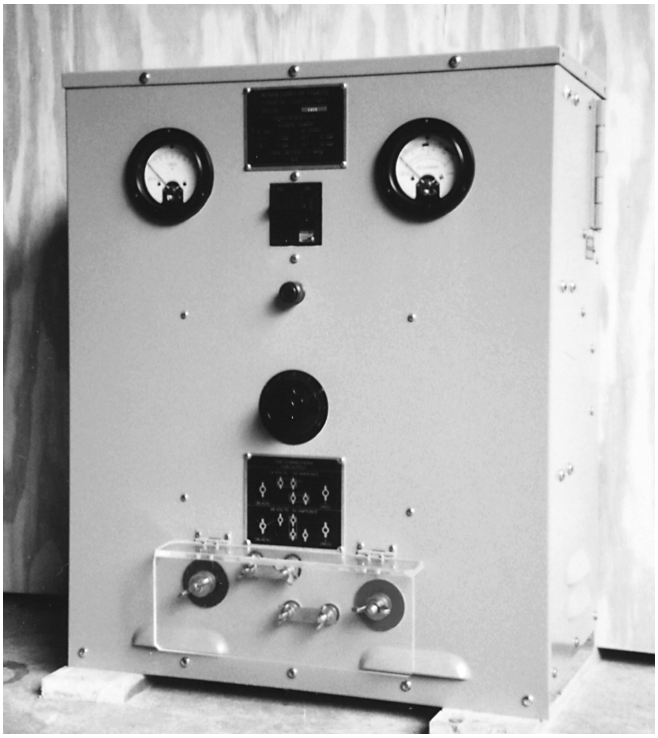
Edmund Scientific, C911 Edscorp Building, Barrington, NJ 08007 • 609-547-8880

The Army Surplus PP-1104C/G Power Supply

Tested by Dave Doty

Things that Work!
tested by *Home Power*

The PP-1104C/G power supply is an Army surplus unit sold by PV dealers as a high current battery charger. I decided to test one to determine its suitability for use as a battery charger in renewable energy systems.



The PP-1104C/G is a heavy duty unit built to military standards. It is housed in a metal cabinet that measures 23 1/4 inches high, 19 3/8 inches wide, 13 1/8 inches deep, and weighs a hefty 152 pounds. The front panel contains the operating controls and connection points for the DC output. The ac input power to the unit is connected through a standard 4/0 box on the rear of the cabinet. A small hinged door is located on the right side of the cabinet near the top. This provides access to a terminal strip for input voltage selection. Cooling air flows into the unit through a grill on the bottom of the cabinet and louvers on the front, sides, and rear. The warmed air is expelled by a fan located behind a grill on the rear of the cabinet near the top. The grill protecting the fan has holes large enough even for adult sized fingers to fit through, so caution is advised.

Packaging and Documentation

The unit comes packaged in a large, extra heavy duty, double wall cardboard box. Styrofoam blocks protect the corners, top, and bottom of the charger. With a weight of 152 pounds (without shipping container), you will want to use a hand truck to move it around. My unit was loaded into my truck with a forklift at Earthlab in Willits, California. When I got home, I slid it down a large plank right into my shop. Then I simply jockeyed it into position with a hand truck.

The documentation that comes with the charger is typical military stuff. Although the original issue date was 1964, my manual has revision dates up to April 1982. This leads me to believe that my charger is much newer than advertised. The only part of the manual I found useful was the connection diagram for selecting the input voltage. The connections for selecting the output voltage are printed on a label on the front of the charger. The manual also contained explicit instructions on how to totally destroy the charger to prevent it from falling into enemy (the Power Company?) hands.

Specifications

Input power to the unit can be supplied at either 115 or 230 volts ac, single phase at 60 Hz. Full load input current is 24 amps at 115 volts or 12 amps at 230 volts. The output voltage is variable from 11.5 to 17.5 Volts DC when configured for 14 Volt operation and variable from 23 to 35 Volts DC when configured for 28 Volt operation. I found that my unit actually put out a little higher voltage than specified. The output current is rated at 100 Amps at 14 Volts or 50 Amps at 28 Volts. The ac ripple is rated at 0.9% (rms) and regulation is 6% at 14 volts or 4% at 28 volts.

Controls

The controls, located on the front panel, consist of an ac input circuit breaker, pilot light, eight position rotary tap switch, DC voltmeter and DC ammeter. The pilot light lens has a cute shutter arrangement that can be rotated to reduce the light output for “blackout” conditions. Even with this shutter wide open, the light is fairly dim and must be viewed almost straight-on to be seen. The meters are high quality analog units. I compared their readings to my Fluke digital multimeters during testing and found them to be quite accurate.

Connecting and Testing
I installed a heavy duty #10 AWG three conductor flexible cord terminated with a 30 amp 120 volt plug to supply power to my charger. I chose this method, as opposed to “hard wired” with conduit, because I wanted to be able to plug the charger into different sources of power. For an input voltage of 115 volts, #10 AWG wire is required. If the unit is configured for 230 volt input, it could be wired with 14 AWG wire.

I configured the output voltage for 24 volts and connected it to my system with 1/0 AWG welding cable. This cable was much larger than required but handy so I used it. For 12 Volt systems with a maximum one-way wire length of ten feet, I would recommend using #1 AWG copper wire. For a 24 volt system you should use #6 AWG wire. The positive cable was connected to a 125 Amp fuse in my main battery disconnect. The negative lead was connected to the battery through a 500 Amp 50 milliVolt shunt to allow measuring the charge current. My battery bank consists of eight Trojan L-16 batteries in a series-parallel configuration yielding 700 Amp-hours of storage at 24 Volts DC. The batteries were at approximately 65% of full charge during testing.

To get things warmed up for testing, I severely abused the charger by running it at 192% of its rated capacity for 25 minutes. Then I turned it down and let it simmer at 124% of rated output for several hours. The initial 25 minute warm up period did cause the charger to emit some hot insulation (varnish) odors. I would not recommend this kind of treatment for any length of time.

Next, I ran the charger at different output levels (adjusted by the tap switch) while simultaneously measuring ac input voltage and current, and DC output voltage and current. Measurements were taken with a variety of Fluke digital multimeters and were recorded on paper for later number crunching by my computer. All of these initial tests were conducted on utility power. My next test involved powering the charger by two different generators. Both generators were fairly small, each rated at only 2500 watts. One generator was a 120 volt, 1800 rpm, gasoline fueled Onan and the other was a 120/240 volt, 3600 rpm, propane fueled Kohler. Maximum charger output was 49 Amps DC on either generator without overloading them. I found a more comfortable output level to be in the 39 Amp range. The results, with a calculated charger efficiency, are displayed in the table below.

Reverse Current
The dealers selling these chargers are making a minor internal modification to the unit before shipping them out. The charger will drain power back from the batteries when the ac input power is shut off. On a 12 Volt system, the reverse current drain on the batteries is about 10 Amps DC and around 4 Amps at 24 Volts. To correct this problem, the dealers are disconnecting two resistors that form part of the resistor/capacitor filtering network. This modification is fine if the unit is only used for charging a large battery bank. If these modified units are powering a small load, the output voltage can soar to nearly twice its rated output. This could damage sensitive equipment or cause overcharging of a small battery. On my charger, which I plan to use for a variety of applications, I installed a DPST switch in line with the resistors. This will allow me to manually

PP-1104C/G Power Supply Test Data

	Tap Switch	*DC Volts*	*DC Amps*	*ac volts*	*ac amps*	*Output Watts*	*Input watts*	*% Charge Efficiency*	*% Rated Output*
Utility power 120 volt input	1	24.38	31.0	117.6	12.19	755.8	1433.5	52.7%	62%
	2	25.00	52.0	116.7	19.62	1300.0	2289.7	56.8%	104%
	3	25.50	58.0	115.9	22.73	1479.0	2634.4	56.1%	116%
	4	25.80	64.0	115.3	25.57	1651.2	2948.2	56.0%	128%
	5	26.40	69.0	114.3	28.89	1821.6	3302.1	55.2%	138%
	6	26.60	78.0	113.3	34.18	2074.8	3872.6	53.6%	156%
	7	26.85	86.0	112.0	39.75	2309.1	4452.0	51.9%	172%
	8	27.05	96.0	110.5	46.70	2596.8	5160.4	50.3%	192%
Onan generator 120 volt input	1	23.88	33.0	116.3	12.78	788.0	1486.3	53.0%	66%
	2	24.90	36.0	114.0	14.58	896.4	1662.1	53.9%	72%
	3	25.10	42.0	110.9	17.08	1054.2	1894.2	55.7%	84%
	4	25.45	44.0	109.2	18.51	1119.8	2021.3	55.4%	88%
	5	25.57	49.0	106.0	21.08	1252.9	2234.5	56.1%	98%
Kohler generator 240 volt input	1	24.33	26.0	234.5	5.20	632.6	1219.4	51.9%	52%
	2	24.65	40.0	225.5	7.99	986.0	1801.7	54.7%	80%
	3	25.10	43.0	220.3	8.85	1079.3	1949.7	55.4%	86%
	4	25.48	44.0	216.6	9.30	1121.1	2014.4	55.7%	88%
	5	25.60	49.0	209.8	10.68	1254.4	2240.7	56.0%	98%

disconnect them when they are not needed. Another solution would be to install a relay to automatically disconnect the resistors whenever the ac power is turned off. When charging batteries without the resistors in the circuit, the charger efficiency will increase by approximately 4%.

Conclusion

If you need a high output charger to make better use of your generator's capacity, then the PP-1104C/G power supply is a good choice. This military charger is well built, works well on generator power, and will withstand a fair amount of abuse. The retail price of $425 is very reasonable when compared to other industrial-sized chargers.

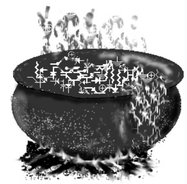
Access

Author: David W. Doty, KB7SFV, 14702 33rd Ave NW, Gig Harbor, WA 98332 • 206-851-2208

Suppliers: Earthlab, 358 S. Main St. Willits, CA 95490 • 707-459-6272

Alternative Energy Engineering, P.O. Box 339, Redway, CA 95560 • 800-777-6609

Building a Battery Box



Bill Battagin

We folks who choose a photovoltaic system as our source of power, enter a relationship much like that we enjoy/endure with our significant other. Sunshine and smiles have long been associated as a symbiotic pair. Occasionally the system (or "Honey") blows a fuse, right? We need to be ready! The design, sense of safety, and construction of my new battery box evolved from living with a photovoltaic system for the last ten years.

In the beginning there was (sun)light

When photovoltaics entered my life, I was a novice concerning electrical wiring, batteries, metering, balance of systems, inverters, and so on. Eagerly, I forged ahead with tape, glue, and bailing wire in hand. At the time I felt my installation was copacetic and safe. Now, though the upgrades made on my system are still fueled by "PV dreams", they are more sophisticated and based on knowledge and experience.

"Drive carefully, Honey"

Safety is the foremost reason that a battery should be enclosed in an appropriate container. Why not just plop them heavy little buggers in some back room somewhere out of the way, bolt a few wires to 'em, and forget it? Well, a battery generates hydrogen gas which is explosive and contains sulfuric acid which can burn skin, eyes, and other parts of biological units. The acid can corrode your once beautiful looking terminals, cables, joints, and surroundings. We've been told before, it's something we already know: a battery (like that boyfriend) can be obnoxious.

So from a safety standpoint, a battery needs to be kept away from and inaccessible to people of all ages. Your enclosure should be able to contain acid in the event of a spill or leakage. It should also collect hydrogen gas and vent it to a safe outside location.

Cost of Bill Battagin's Battery Box

Equipment	*Cost*
Copper bus bar, 1/0 cable, interconnects	$65
Hot air ducting & 12 V fan	$74
1/8 inch Acrylic sheet (4 feet x 4 feet)	$55
1/4 inch AC plywood (4 feet x 8 feet)	$15
One pint each primer, paint, & linseed oil	$10
Misc. caulk, screws, nails, slide bolts	$9
Fiberglass insulation, R-11	$5
Lumber, recycled	$0
1 inch PVC pipe, recycled	$0
Three door hinges, recycled	$0
Total	$233

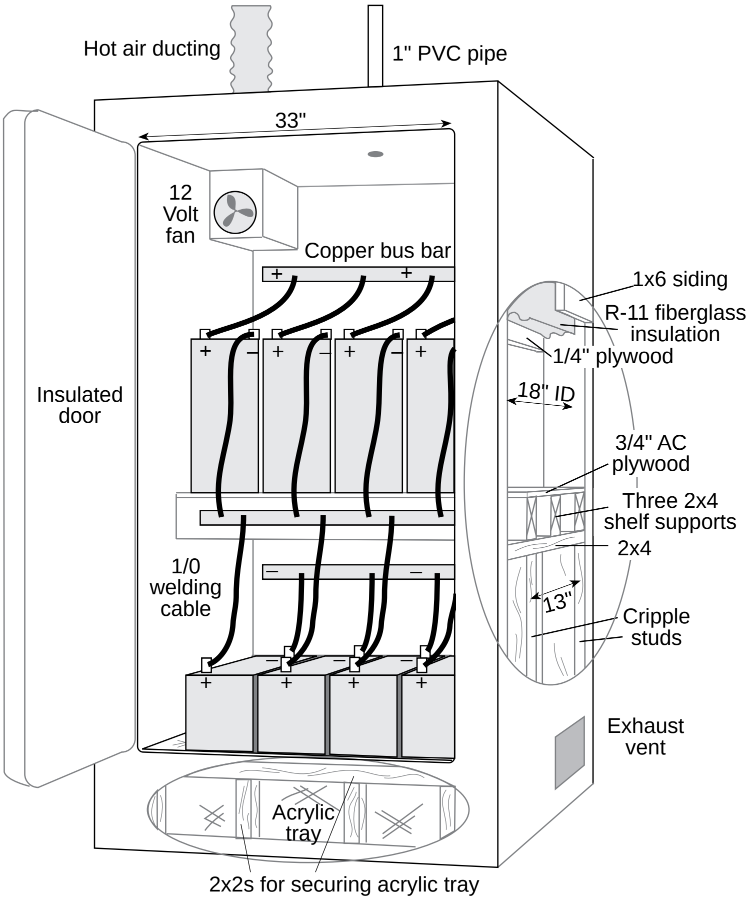
What she'll do

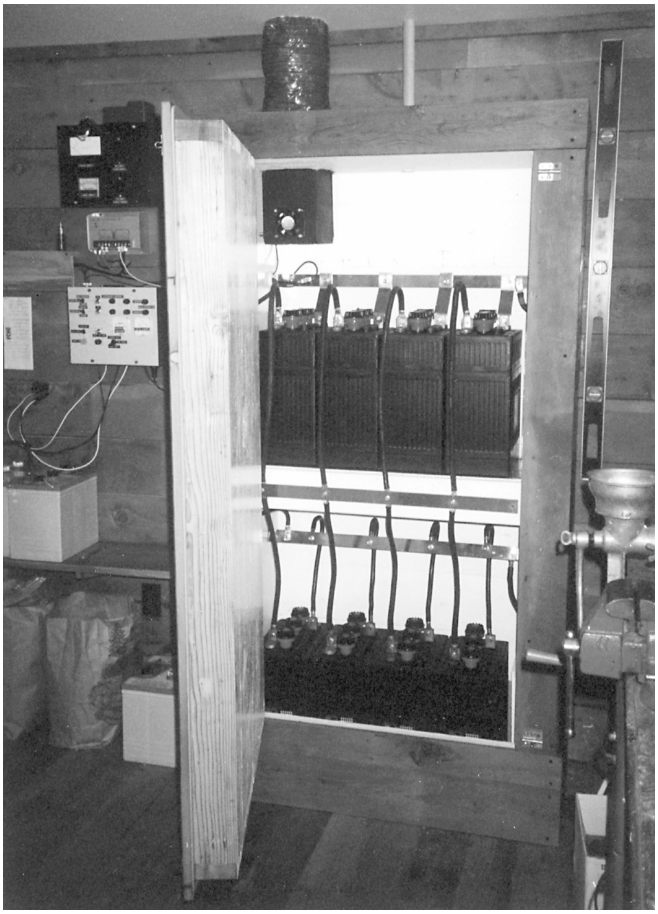
Performance! You want to get the most from your new battery. I chose eight 6 Volt L-16 wrapped-plate lead-acid batteries manufactured by U.S. Energy (1400 Amp-hours at 12 Volts). Somehow when we install our spiffy new (or used) battery bank, we think that we're done! These puppies will last forever. Not! It will be too soon that you are elbows deep in battery cables and sulfuric acid again, changing them out. So we want to get as many miles as we can from this expensive investment. The way you connect your battery, the gauge and materials of your conductors, and the integrity of the electrical connections at your terminals all make a difference. For these low voltage systems, any resistance created by poor connections, too small a wire gauge, and the yuk that builds up means less juice reaches the battery. Keeping dirt and other contaminants away from your battery and connections will increase performance and lifespan.

Another function of a battery enclosure is to regulate the temperature of your bank. That location on the floor, in the back room, in the basement, or outside that you chose for your battery may have satisfied most of their needs. But in the winter, it (she) likes to be warm, in the 70°F range. Don't locate the battery where it will get too warm (over 90°F). Winter warming will have a significant effect on performance, believe me!

Living together

Whether your battery lives inside or outside your home will be determined by many factors: proximity to the PV array (or other energy source) and the inverter, space availability, considerations for venting hydrogen, ease of maintenance, and a method of adding heat to the battery bank. I like the concept of a small power/battery shed separate from my house, but it would increase the cost of my system in time and money. An inside location can be safe and functional, if done properly. And it's definitely easier to add heat.





The previous relationship

My last battery bank consisted of twelve 220 Amp-hour U.S. Energy 6 Volt golf cart batteries which lasted about five years. At 1320 Amp-hours in a 12 Volt configuration, the battery bank gave me about a five to six day storage capacity. My C/40 rate for charging (my 11 photovoltaic modules deliver 33 Amps) seemed to treat the battery with respect. In any big emergency I still use my grid connection for back-up. I chose to stay with a lead-acid battery because it is recyclable and easily obtainable. Eight L-16 batteries require fewer connections, cables, and joints than a comparable nickel-cadmium battery bank. The space required for a nickel-cadmium bank is significantly larger, since they have a lower energy density. Finally, I found a good deal on these L-16s. This new bank gives me a bit more storage at 1400 Amp-hours. We could talk about usable storage (you should only discharge lead-acids 50–80% whereas nickel-cadmiums can be fully discharged), but uh, I hear my mom calling.... Onward!

Making it work

My battery box was constructed somewhat like a closet. My brother, Dr. Goose, built the four inch stud frame construction walls, insulated and put exterior siding on them. The exterior siding was once the decking for a roof, some nice looking 1x6 Douglas fir. Four L-16s weigh about 536 pounds so he installed cripple studs under the end support for the three horizontal 2x4s that support the batteries. The door on the box is also four inches thick and is large to allow easy access (see diagram left). The walls, ceiling and door are insulated to R-11, with an inside sheathing of 1/4 inch AC plywood. The existing south wall in the utility room is the back wall of the battery box.

I primed and painted the plywood with a high quality enamel paint. Though certainly not acid proof, it would safely shed any vagrant acid down to a 1/8 inch thick acrylic “tray” in the bottom of the box. The tray is the length and width of the box by ten inches tall, large enough to contain all the acid in one battery. To build the tray, cut the bottom (18 by 33 inches), two sides (10 by 33 inches), and two ends (10 by 18 inches) from a 48 by 48 inch sheet. The bottom of the box had plenty of backing and nailers to solidly support the acrylic sheets which formed the tray. Holes were predrilled and countersunk for the 1 5/8 inch sheet rock screws which secure these pieces to the walls and floor. All corners, screw heads, cracks and penetrations were caulked with 100% silicone seal.

Must have been something I ate
I dealt with hydrogen gas in two ways. First, I installed Hydrocap battery tops on all the cells. Voila, 90% less hydrogen to worry about. Second, a one inch PVC pipe exits the top of the box to allow any gas to escape to the great outdoors (would you please do that outside?) Remember that a hydrogen vent pipe must always rise upward. Horizontal runs should have a little slope so the gas rises to an elevated location, away from ignition sources. Another feature of Hydrocaps is less yuk to clean off the top of your batteries and your terminals and cable connections. I love it. Wiring to and from the inverter, controller, and loads is caulked where it penetrates the walls.

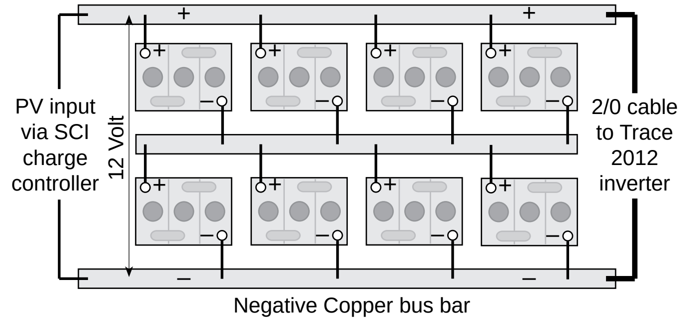
Keepin' her warm
I built my battery box in a back room of my house, a utility/shop space on the north side of the house. It's a cool place — my refrigerator lives there. But batteries perform better at warm temperatures, especially lead acids (see *HP*#9, page 25–26 for a temperature comparison of lead acid batteries). Cold lead acid batteries (at 40°F) have only 80% effective capacity than at 78°F — having cold batteries is like removing some of the batteries from your bank!

To bring my batteries up to a happy temperature, I installed four inch insulated ducting at the ceiling above my woodstove. This vent comes into the top of the battery box and then enters a sheet metal enclosure inside the top. This enclosure drops about ten inches down into the box and is six inches square. On one side of the enclosure towards the bottom, I cut a 3 1/2 inch round hole where I attached a 12 Volt DC brushless fan. I mounted the fan below the top of the box to prevent hydrogen gas from entering this duct. The fan draws 80–90°F air heated by the woodstove (it's best to pull with a fan, not push) into battery box, warming the batteries. Cool air is exhausted into the room at the bottom of the box on the opposite side.

The uniform heating of all cells was considered in this design. Some baffling may be required after further testing. At this point, I manually turn on and off the fan (on at 10 PM and off at 7 AM), but my mind is conjuring up some schemes for an automatic system.

Solar heating is a viable option. I heat the battery for the solar electric system at my store with a solar hot air panel using a sun synchronous DC fan ducted into my exterior add-on battery box. It works like a champ.

Good Connections
Following Richard's instructions in *HP*#7, page 36–37, I made and soldered ends onto 1/0 welding cable for my interconnects. Basically, I used short (about 2 inch) pieces of soft copper tubing, stuffed a stripped end of the cable into the tubing. I flattened one end of the tubing with a hammer, soldered the connection, and drilled a hole in the flattened end.



Eight L-16s cross wired for 1400 Amp-hours at 12 Volts

I wired this new battery bank differently from my old bank. I used three lengths of 3/16 inch by 1 1/2 inch copper bus bar to cross wire the battery (see diagram above). Each bus was mounted to the box's interior using one inch porcelain standoffs, secured at both ends with sheetrock screws. The middle bus bar, the heavy gauge cables, and the connecting points for the PVs and inverters allow a nearly identical input and load at each battery. Each individual cell sees a uniform charge and discharge. The cross wiring prevents discharging (and eventually losing) some cells more than others in the battery pack. All the cells should reach float voltage under equalizing charge sooner as well.

The bus bars were placed to ensure that a careless move with a metallic object such as a wrench would not short the battery. I could have bolted the buses directly to the battery terminals, but I prefer to have clear and easy access to the tops of my batteries for cleaning. And, well, I had some extra bus bar, so I bent it and used it for some of the interconnects.

(Almost) Perfect Match
A little wood dough here and there, linseed oil, weatherstripping the door, a couple slide-bolt catches, and we're done. I look way forward to the distant prospect (ten years?) of changing out the L-16s to a high inertia flywheel, or a hydrogen/fuel cell/hydride storage system. In the meantime, I'm gonna go smell the roses (with my honey, of course!).

Access
Bill Battagin, Feather River Stove Works, 5575 Genesee Road, Taylorsville, CA 95983 • 916-284-7849. Questions? If you write, please send an SASE or call between 6–7 AM or 8–9:30 PM.

12/24 Volt fan: Graingers, local phone book. Copper bus bar: check local steel & metal supply houses. Acrylic sheet: check plastic fabricators

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Hydraulic Ram Pump

adapted from *A Manual for Constructing and Operating a Hydraulic Ram Pump* by Kurt Janke & Louise Finger

Here's a design for a hydraulic ram pump that requires readily available materials and few tools to construct. Ram pumps are commercially available that are potentially more efficient and durable, but are also more expensive. This pump can be built for under $75, and is capable of pushing 130 gallons per day 150 feet high, with a drive head of 20 feet.

A ram pump uses the potential energy of falling water to lift a fraction of that water to a higher elevation. (See Figure 1) Water accelerates through the drive pipe and open waste valve. Its velocity increases until the flow and upward force causes the waste valve to shut suddenly. The momentum of water produces a short-lived pressure, called the "ram", which is greater than that in the pressure tank. This causes a small amount of water to be released through the check valve into the tank. After the exerted energy is transferred into the pressure tank, the pressure below the check valve is less than that in the tank. The check valve shuts and the waste valve falls open, allowing the cycle to repeat continuously. The compressed air in the tank acts like a spring to drive the water that had passed through the check valve into the delivery pipe and on to a higher elevation.

The output volume of a ram pump is determined by the drive head, delivery head, amount of available water, and stroke length of the waste valve. The greater the drive head, the greater the acceleration in the drive pipe, and thus the potential energy at the pump. A longer stroke length also allows a greater velocity to reach the pump. Similarly, the greater the flow, the greater the mass of the moving water, and thus greater the potential energy. The greater the delivery head, the greater the energy required to pump a given volume of water.

Tools required for this homebrew ram pump are: two 24 inch pipe wrenches, two 7/16 inch wrenches, utility knife and/or circle cutter, drill and metal bits, #8 tap, and a screwdriver. For materials, see the list on right.

Waste Valve Assembly

Figure 2 illustrates the waste valve assembly. Use only half of the 1 1/4 inch union for the base/seat of the valve. It will be necessary to drill a 3/8 inch hole through the 1 1/4 inch male plug and a 5/16 inch hole in the shoe heel material. Attach the shoe heel disk to the bottom of the all-thread by securing the lock nuts and washers around it. The rubber washer at the top of the valve serves to reduce the stress induced on the adjustment nuts by the continuous pounding of the ram. The relatively soft all-thread used in the waste valve might stretch (or even break occasionally), so we recommend having replacements on site, or using a more durable material.

Be as accurate as possible with the tolerance between the all-thread and the plug. Cut the shoe material accurately round, and center the holes carefully. The success of the pump depends on the waste valve running up and down precisely as well as how it seats on the union.

Materials Required

Pump
10 liter fire extingisher (1" thread[@])
1/2" gate valve
Two 2" tees
1" tee
2" 90° elbow
2" x 4" nipple
1" x 4" nipple
Two 1" close nipples
1/2" x 4" nipple
1/2" x 2" nipple
Two 2" x 1" reducer bushings
2" x 1/2" reducer bushing
1" x 1/2" reducer bushing
Teflon tape
Waste Valve
1/4" tee
1/4" close nipple
1/4" male plug
1/4" union
5/16" x 10" all-thread*
Two 5/16" nuts
Two 5/16" lock nuts
3/4" ID x 7/8" OD flat washer
5/16" ID x 3/4" OD flat washer
5/16" ID x 1" OD flat washer
rubber washer
7/8" diam. x 3/8" shoe heel material[+]
Check valve
Two 2" x 3/4" reducer bushings
3/4" close nipple
#8 x 1/4" machine
tractor tire rubber or leather[+]

[@]Other types of tanks or larger diameter pipes may work better, as fire extinguisher bodies are often made from soft aluminum with a potential for thread failure.

*A steel bolt with threads over its full length will also work and may be more durable.

[+]Available at shoe repair or leather-working shops.

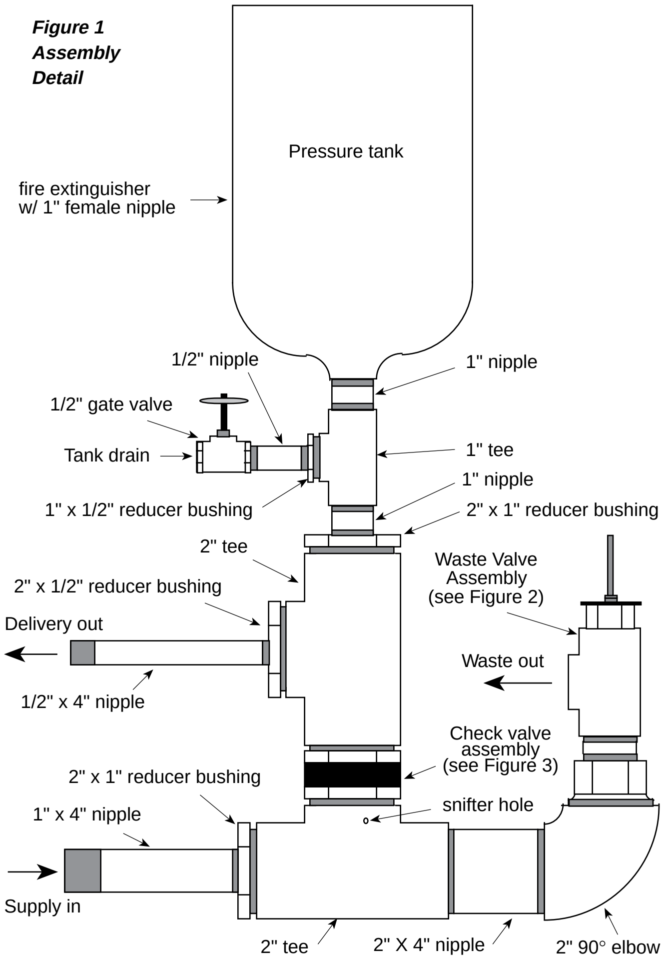


Figure 1 Assembly Detail

Check Valve Assembly

Figure 3 illustrates the check valve assembly. A reducer bushing is used as the valve seat. Drill a 1/16 inch hole in the bushing flange and thread the hole with a #8 tap. From tough rubber, such as a tire, cut a disk approximately 1/8 inch thick so that it fits loosely inside the bushing. Secure the disk with a screw. Cut additional disks to be used as spacers and support between the two bushings. Use Teflon tape on the nipple threads to prevent leakage.

Thick leather makes excellent check valve material, as well. Putting a heavy washer acting as a weight on top of the valve material may also increase the sealing ability of the valve. This washer should be centered over and cover the width of the seat, and can be secured with a short bolt and locknut, with a small washer on the underside.

Pump Assembly

Valves, fittings, and pipes are assembled together as shown in Figure 1, using two pipe wrenches. In the same fashion as the check valve, all threaded pipe should be Teflon taped and tightly secured.

A very small snifter hole may be drilled in the tee below the check valve. This will allow air to be sucked into the pressure tank to replace the air that inadvertently mixes with water and exits through the delivery pipe. Many homemade pumps just leave this hole open, but efficiency can be lessened as water squirts out during the ram. Without a snifter, the pressure tank will eventually fill with water and need to be emptied regularly.

One marginal remedy is to put a nail through the hole with the head on the inside, bending the shank on the outside to prevent the nail from being sucked into the pump. Shoot for a loose back and forth fit so that air can be sucked in, yet the head of the nail can close off the inside of the hole during the ram.

Installation, Operation and Maintenance

Both the drive and delivery pipes should have a shut-off valve and union on the pump end of the pipe. The only mounting apparatus needed is a stable pad for the pump to rest (i.e., a board). The pump should be held upright and installed so that the waste valve unit is clear of water and obstruction.

Figure 3
Check valve detail

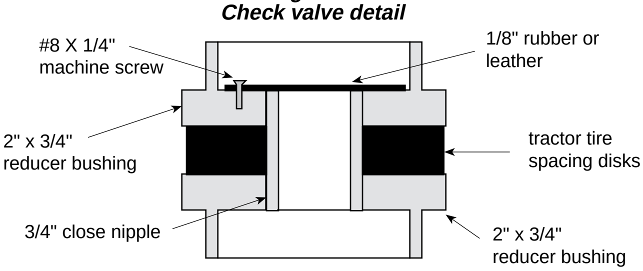
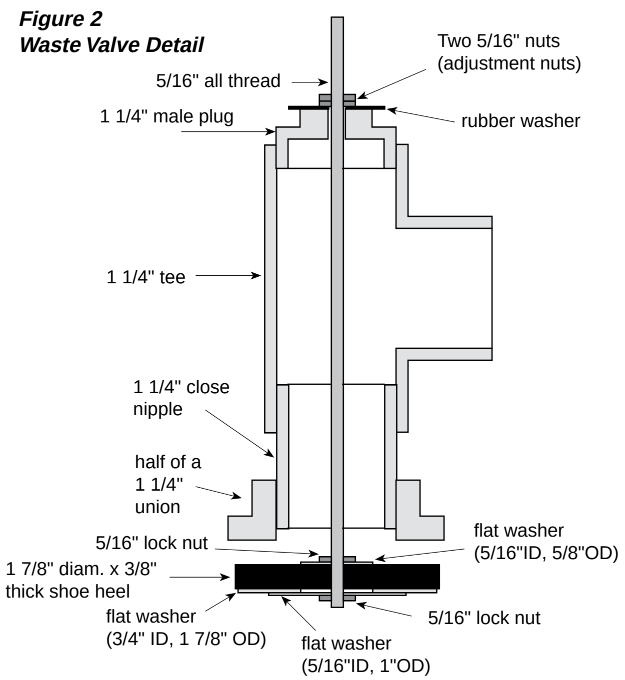
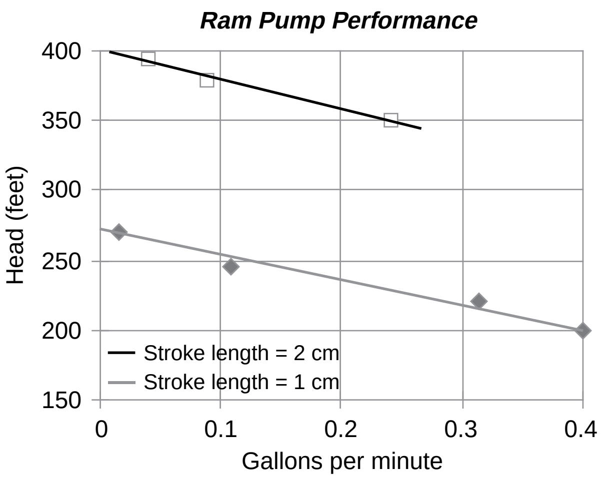


Figure 2
Waste Valve Detail





To start the pump, set the stroke length between one and two centimeters and open the inflow valve, keeping the outflow valve closed. Manually open and close the waste valve until it will operate on its own. Wait approximately one minute and then crack open the outflow valve a little at a time. If the pump fails to continue operating, repeat the process, lengthening the lag time prior to opening the outflow valve.

The stroke length can then be experimentally varied to optimize pump output. Shorter stroke lengths work better at lower flows and longer stroke lengths are better for higher flows. A longer stroke length provides a greater velocity in the drive pipe, thus increasing the potential energy in the falling water at the pump. However, more water is "wasted" which may result in possible source depletion.

If the pump is operated continuously without a snifter valve, it should be drained, via the tank drain, before the pressure tank becomes full of water. One should expect to drain the tank approximately once a month, unless you have a working snifter valve. The rubber used in the valves should withstand continuous use for several years. Periodic inspections will help determine when replacement is necessary.

This homemade ram pump is a "folk project", with improvements by each person who built it. If you find new solutions for keeping the waste valve in better alignment, or a good snifter design, please share them.

Access

Louise Finger & Kurt Janke developed this pump through Humboldt State University's International Development Program (see page 78). For information, call 707-826-3619.

Contact authors through Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95521 • 707-822-7884 (voice) • 707-822-8640 (Computer BBS)

HSU's International Development Technology Program

Michael Welch

We westerners often see or hear about wonderful projects helping folks in developing countries. But how often do we hear of the projects that fail? That well-intentioned cardboard solar cooker wilted in the first rain. The wind-powered water pumper was abandoned because no local was trained to maintain it. Humboldt State University's International Development Technology Program combats these problems with its emphasis on cultural sensitivity, appropriate solutions, and sustainability in their international projects.

The International Development Technology (IDT) graduate studies program is offered through the Environmental Resources Engineering Department at HSU. This Masters of Science program is designed to provide its students with a broad education in development issues.

It admits only a handful of students each year, and gives them a solid basis for improving the health, quality of life, and environment for people in developing countries. This program teaches students to apply appropriate technology to those that need and deserve it the most.

The IDT program not only gives the students the technical skills they need, but teaches cultural sensitivity and respect. Students learn how to fund their projects, even when government money is hard to get. Of course, studying with top environmental engineering and international development professors like Dr. Peter Lehman, Dr. Robert Gearheart, and Dan Ihara help these students obtain funding. The IDT faculty are acclaimed in their various fields.

IDT students come from a variety of backgrounds. Graduates have had previous experience in engineering, child development, Native American studies, accounting, nursing, marine biology, and even fashion design. IDT students, because of their backgrounds and maturity, often advise undergrads who are in HSU's Environmental Engineering programs.

Some IDT Examples

Gail was a nurse who felt she could give more than she had been while working at local high-tech hospitals. She heard about and enrolled in the IDT program, which gave her the skills she needed to teach Central American mothers the principles of rehydration. Because of diseases common in developing communities, dehydration is a serious and often life-threatening problem.

Another IDT student, Cristina, has strong interests in renewable energy. Her IDT graduate project is a study of the effectiveness of a joint NREL and Brazilian utility rural electrification project. This project is not a grass-roots type effort as most IDT projects are, but a top-down organizational project. She is working for the Brazilian Electricity Research Lab and NREL, not the people.

NREL has teamed up with U.S. equipment manufacturers to test the market for photovoltaics in Brazil. They provide 500 modules and batteries per state, supplying 12 to 100 homes per village and a larger system for the school in each village. Cristina is documenting how the systems are used and is looking into making more systems available.

David Potter's project studied using alcohol fuels on Ukrainian collective farms. He was in the Ukraine from June to November 1993. The Ukrainians took advantage of his skills to help teach their younger children environmental education and their older children American literature and history.

His study uncovered two big roadblocks. The first was expected: cumbersome bureaucracies. The second was more of a surprise. Ukrainian people were frightened of alcohol fuels, because they thought making fuel might limit access to drinking alcohol. Consuming alcohol is a major cultural aspect of the Ukraine. Everybody seems to drink and many make liquor, as well. David concluded that this cultural fear would have to be dealt with, that Ukrainian scientists are quite capable of developing and implementing the necessary technologies, that plenty of farmland is available to grow the fuel corn, and that financial and bureaucratic restraints would have to be overcome. David will be going back to the Ukraine in August to

introduce a sister to HSU's CCAT (Campus Center for Appropriate Technology) at Cherkasy Engineering and Technical Institute near Kiev.

Local projects = international experience
Success stories abound within our local community. Part of the IDT curriculum includes classes in development project design, project management, and evaluation, and finally, development technology. Within the framework of these courses, students go into the local community to find, design, and implement projects that they can apply to their future third world experiences.

I have been connected with several of these projects. One resulted in the design and fabrication of a ram pump (see page 74). Another project resulted in the difficult development of a spring on my own property. Still another helped harness Cara Smith's creek so she could have water at her rural home during the dry season (see *HP*#40 for review of the Folk Ram Pump).

These projects all had one thing in common: energetic and hardworking students who apply experiences with local projects to international development.

With my spring development project, the students treated me like a developing country host. They delved into my needs and learned the financial and environmental constraints that would affect the project. They presented a straightforward proposal and budget, and stuck to it the best they could. When things varied from the original plans, as such projects always do, the students were quick to come up with solutions and involve the "host country" (me) to the degree the host required.

Many IDT students have gone on to make sustainable international development their life's work. Others have moved on to HSU's Environmental Engineering Program to take part in the more technical and scientific aspects of community development. Still others have gone on to "mainstream" type jobs.

All is not perfect, though
Unfortunately, this one-of-a-kind program suffers due to lack of support from HSU's administration. Even though the IDT program seems to fit better than most into the stated mission and goals of the University, it is not exactly the favorite son.

So little support comes from the University that the IDT professors have, in essence, become volunteers. This program exists almost entirely because a handful of instructors has made it a labor of love. They spend a lot of time and energy with IDT students in addition to their regular faculty load.

Ideally, the IDT professors would like to see a full time coordinator for the program, and the academic support to double the size of the program to 12 students. Their long term vision sees only the sky as the limit, and the earth as the beneficiary.

Access
For information on the program and its projects: International Development Technology Program, Humboldt State University, Arcata, CA 95521 • 707-826-3619

Author: Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95521 • 707-822-8640 (Computer BBS) • 707-822-7884 (voice)

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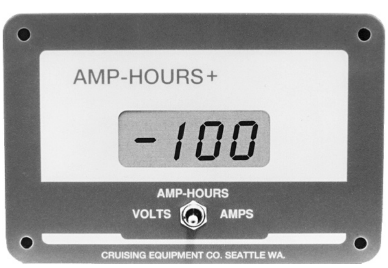

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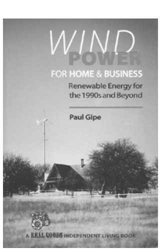

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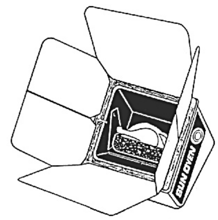

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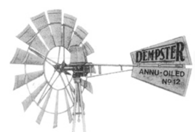

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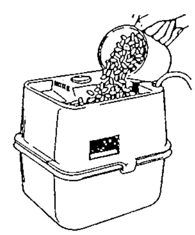

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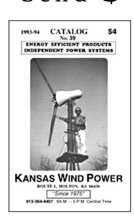

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U2624	2600	24	
U2624SB	2600	24	60
U2232	2200	32	
U2232SB	2200	32	45
U2536	2500	36	
U2536SB	2500	36	40
U2548	2500	48	
U2548SB	2500	48	30
M1512	1500	12	70
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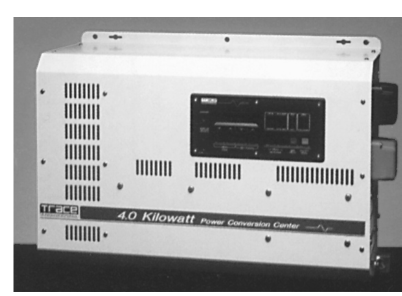

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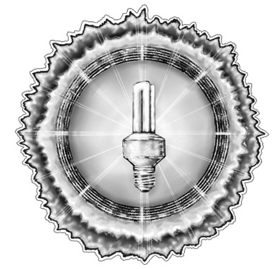

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916–475–0830 Subscriptions and Back Issues
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Tek-Tron's RV-12 Fluorescent DC Light

Things that Work!
tested by *Home Power*

Therese Peffer

Last winter I took an art class at the local college. For my work at home, I needed a warm bright light that evenly covered a fairly large area. I wanted a 12 Volt DC light that didn't draw much from my battery. And I wanted something easy to install that would fix securely over my work area. I found just the thing with Tek-Tron's under the counter fluorescent light fixture, the RV-12.

The light came in a reinforced cardboard box. The flat rectangular fixture is perfect for installing under counters or shelves. The metal case feels nice and sturdy and the clear (not yellow!) plastic reflector casts a fairly warm even light over a broad area.

The RV-12 contains a common 13 Watt compact fluorescent tube (two-pin plug in), found at many hardware stores. The light comes with a one year warranty. Tek-Tron also has a 9 Watt design of this fixture; it accepts a 9 Watt compact fluorescent bulb.

The RV-12 is rated 12 Watts, 12 Volts ac or DC. We measured 1.042 Amps at 13.22 Volts DC, or 13.78 Watts when initially warming up and 1.062 Amps at 12.22 Volts DC, or 12.98 Watts thereafter. The higher the voltage, the greater the current draw will be. The voltage limit of the light is 9.5–19 Volts, which works great with my 12 Volt lead-acid battery system.

Installation was simple. A metal template is included to mark the location of the two screws (also included) that hold the light. A minor touch, but it made installation much simpler for me. The light slid in place on the two screws after just a few minutes with a screwdriver. A third smaller screw is used to prevent the light from slipping off the screws. The lens comes off and snaps back on easily to accommodate the final screw. The fixture is not polarized and does not come with a plug. This was no problem for me — I wired it directly to my 12 Volt circuit breaker.

The $49.95 retail price tag may seem high to some, but the high quality of this efficient light substantiates the cost. This is no flimsy piece of hardware, but a nice looking, well-made product that sheds light on the subject while taking it easy on your batteries. Consider that a good quality, efficient ac light with a reflector and fixture will cost about $25 to $30, and then you need an inverter to run it. If you look around at other DC compact fluorescent lights, you'll notice they require an expensive ballast and do not come with a fixture.

Different applications call for different lights. The RV-12 is a quality DC light that will light up your life quietly and efficiently.

Access

Tested by Therese Peffer, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179

Tek-Tron Enterprises Inc, 3122 W. Alpine Ave., Santa Ana, CA 92704 • 714-641-1988

Distributed by Energy Outfitters, 136 S. Redwood Hwy, PO Box 1888, Cave Junction, OR 97523 • 800-467-6527

Flexible Cables Are Here

John Wiles

The new symbol at the top of this Code Corner is a stylized version of the Native American symbol for the Sun Kachina which represents a spirit associated with the sun. It is also the symbol of the Photovoltaic Design Assistance Center (PVDAC) at Sandia National Laboratories which supports the research leading to these columns.

In Code Corner *HP*#40, the problems associated with using welding cable and non-UL Listed battery cables were discussed. There is now a solution to the stiff #@$% building cables — flexible building wire type cables with over 400 strands of very small wire.

These cables are marked USE, RHH, and RHW which will satisfy the local electrical inspector who was not happy with welding or battery cables. They are made in several sizes including 1/0, 2/0, and 4/0 AWG and larger sizes. They are listed by Underwriters Laboratories, and best of all, they are or shortly will be available from many of the PV distributors. Ananda Power Technologies has a supply now. (Distributors: see Access at the end of the article.)

Conduit Fill

While these cables are as easy to use as welding cables, some thought must be exercised when putting them or any other cable in conduit. The National Electrical Code (NEC) has specific guidelines about the number of conductors that can be placed in a given size of conduit. This new cable has a thicker insulation than the insulation on THHN building cables. The insulation is even slightly thicker than that found on typical USE, RHH, RHW building cables. The NEC allows conduits to only be filled to 40% of the internal cross sectional area unless they are less than 24 inches long and then the fill can go to 60%. The table below presents some of the data for certain flexible cables. The actual cable purchased may differ in outside diameter and should be measured.

Flexible Cable in Conduit

		Conduit Sizes (in.)	2	2.5	3	3.5
		Area (sq. in.)	3.36	4.79	7.38	9.9
Wire size	*OD (in.)*	*Area (sq. in.)*	*% fill for each conductor*			
1/0 AWG	0.68	0.363	10.8	7.6	4.9	3.7
2/0 AWG	0.73	0.419	12.5	8.7	5.7	4.2
3/0 AWG	0.84	0.554	16.5	11.6	7.5	5.6
250 kcmil	0.96	0.724	21.5	15.1	9.8	7.3
350 kcmil	1.08	0.917	27.3	19.1	12.4	9.3

Example: Conduit Sizing

From ampacity calculations (see Code Corner, *HP* #40), it has been determined that two 250 kcmil cables must be paralleled to achieve an ampacity of 408 amps. This would mean that four cables (two positive and two negative) would be needed in the conduit. The NEC allows the equipment grounding conductor for DC systems to be run outside or inside the conduit and a decision is made to run the equipment grounding conductor in a separate conduit.

From the above table, it can be seen that each 250 kcmil conductor will provide 9.8 percent fill in a three inch conduit so four such conductors would fill it to 39.2% (4 x 9.8). This is below the 40% fill limitation for conduit runs over 24 inches in length. If the conduit run were less than 24 inches, a 60% fill factor could be used. The table shows that a single 250 kcmil cable provides 15.1% fill in a 2.5 inch conduit and four cables would fill it to 60.4% violating the NEC 60% requirement. Therefore, the requirement would still be for a three inch conduit — even for runs less than 24 inches.

More Details on Ampacity Calculations

Code Corner in *HP*#40 mentioned that many circuit breakers and fuses were rated for only 75°C conductors. In fact, many of the circuit breakers and fuses used in residential electrical systems are rated for only 60°C which matches the temperature rating of non-metallic sheathed cables like MN and UF. These temperature ratings are specified on cables, fuse, circuit breakers and the like to avoid operating any particular component over its maximum temperature rating.

For example, fuse and circuit breakers generate heat when current is flowing through them. If

a circuit breaker rated for only 75°C conductors was connected to conductors rated at 60°C, then the circuit breaker (when carrying full current) might overheat the 60°C conductors and cause the insulation to fail. In the same manner, if 90°C conductors were operated at full current when connected to a 75°C rated fuse, the hot 90°C conductors might cause the fuse to overheat and blow prematurely. When calculating the cable sizes to use for module wiring this situation creates an additional complexity.

Because PV modules operate at high temperatures (50–75°C) on warm days with little wind, cables rated for 90°C are usually used for the module interconnections. Exposed cables are usually USE types and cables in conduit are usually THHN or XHHW — all rated at 90°C. The ampacity of these cables must be derated for temperature using the derating factors given in Tables 310-16 and 17 in the NEC. The derating of conductors was covered by Code Corner in *HP*#37. An example of the new considerations follows.

Ampacity-Temperature Example

Four Solarex MSX-64 modules are to be connected in parallel on a 12 Volt system. Conduit is to be run from the last module junction box down to a Square D load center with DC-rated QO circuit breakers. The QO breakers are marked for 75°C conductors. THHN cable with a 90°C temperature rating is to be used for all of the wiring and it will be temperature derated because the modules operate at 65–70°C.

The short-circuit current of the MSX-64 is 4.0 Amps. Four in parallel will have a combined ampacity of 16 Amps which must be multiplied by 125% to allow the cables to operate at no more than 80% of rated ampacity. This yields a requirement for a cable ampacity of 20 Amps. Number 10 AWG THHN has an ampacity of 40 Amps at 30°C but must be derated by a factor of 0.58 at the module junction box because of the high temperature. This gives a derated ampacity of 23.2 Amps which meets the requirement of at least 20 Amps. At this point, the temperature rating of the device connected to the other end of the THHN conductors must be considered.

The Square D QO breaker has terminals rated for 75°C conductors in an ambient temperature of 40°C. If a number 10 AWG 90°C conductor was attached to these terminals and operated at high current levels, the temperature might approach 90°C and overheat the breaker. To determine if the current being carried by the 90°C conductor is too high for the breaker, the following calculation may be made. A number 10 AWG, 75°C rated conductor has an ampacity of 35 Amps at 30°C ambient air temperature. At 40°C this ampacity derates to 30.8 Amps (35 x 0.88). These calculations indicate that a number 10 AWG conductor can carry up to 30.8 Amps in an ambient temperature of 40°C and not cause problems with the circuit breaker. The actual ampacity requirement is only 20 Amps which indicates that there should be no problem. For other conditions of temperature and current requirements, there might be a problem.

In summary, the 125% of the short-circuit current requirement at the high temperature end of the cable must be less than the temperature derated ampacity of the cable using the ampacity ratings for the actual temperature rating of the conductor. The 125% short-circuit current requirement at the low temperature end of the cable must also be less than the temperature derated (if any) ampacity of the cable using the same size cable but rated at the temperature rating of the terminals of the connected device.

Another consideration is that flexible conduit, if used, is rated at 80°C when dry and only 60°C when wet. In the outdoor, exposed locations for PV modules, this 80/60°C temperature rating might have some impact on the size of the cables used.

With cables and overcurrent devices under control, the next issue of Code Corner will deal with Disconnects.

Access

Author: John Wiles, Southwest Technology Development Institute, POB 30001/Dept 3 SOLAR, Las Cruces, NM 88005 • 505-646-6105

National Electrical Code - 1993, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

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M.R.E.A. 1994 Summer & Fall Workshop Series

The Midwest Renewable Energy Association’s annual Energy Fair is a weekend packed with displays and workshops. This year, 93 one hour workshops (usually running an hour and a half) have been scheduled. The pre-fair workshops, wherein, students actually assemble renewable energy systems that are on display, really power the event! In response to growing interest in these in-depth, hands-on workshops, the MREA is pleased to announce their continuing education workshop series. The summer/fall session begins with three workshops taking place just prior to the Fair. Unlike past years, we will continue to offer one and two day workshops all summer and throughout the fall. Call or write MREA for details on individual workshops.

May 31 -June 9 — Wind/PV Hybrids, design & installation workshop. Solar Energy Institute, Carbondale, CO. Workshop location is Amherst, WI. This pre-fair workshop will install the photovoltaic and wind systems for the Energy Fair Fairgrounds. — Cost $400. per week

June 9-19 — Photovoltaic System Design and Installation. Jim Kerbel, Photovoltaic Systems, Amherst, WI and Christopher LaForge, Great Northern Solar, Port Wing, WI. This pre-Fair workshop will install the photovoltaic and electrical systems on the MREA’s Model Home and tie in the fairgrounds soundstage and workshop locations. Cost $100.

June 14, 15 & 16 — Masonry Heater Workshop. Building an Albert Barden/Finnish Contraflow style masonry heater core. Tim Custer, TNT Masonry Heaters of Cleveland, OH. This pre-fair workshop will construct a home-sized masonry wood-fired heater at the MREA Energy Fair Fairgrounds. Cost $200.

July 23 & 24 — Detailing for Energy Efficiency in Home Construction — Mark Klein, Gimme Shelter, Almond, WI Workshop located in Amherst, WI. Cost $200.

July 30 & 31 — Building Photovoltaic / Hot Water Hybrid Modules — Dr. Richard Komp, SunWatt Corporation, Addison, ME Workshop located in Amherst, WI. Cost $200.

August 13 & 14 — Photovoltaic Powered Home Systems — Jim Kerbel, Photovoltaic Systems, Amherst, WI. Workshop located in Amherst, WI. Cost $200.

August 26 & 27 — Home-Sized Wind Systems — Mick Sagrillo, Lake Michigan Wind & Sun, Forestville, WI. Workshop located in Forestville, WI. Cost $200.

September 10 — Window Quilting for Moveable Insulation — Beverly Nelson, Stevens Point, WI. Workshop located in Stevens Point, WI. Cost $75

September 17 & 18 — Residential Solar Domestic Hot Water — Richard Lane, Packerland Solar, Green Bay, WI. Workshop located in Green Bay, WI. Cost $200.

September 23 & 24 — Wind/Photovoltaic Hybrids — Mick Sagrillo, Lake Michigan Wind & Sun, Forestville, WI and Jim Kerbel, Photovoltaic Systems, Amherst, WI. Workshop located in Forestville, WI. Cost $200.

September 30-October 2 — Batteries and Inverters, applications for home-sized systems — Richard Perez, Home Power, Ashland, OR. Workshop located at Treehaven Learning Center, Tomahawk, WI. Cost $250.

October 14-17 — How to Build an Affordable Natural House Using Timber Frame, Straw/clay, Earth Plaster, and Earth Floor — Robert Laporte, Natural House Building Center, Fairfield, IA. Workshop located in Amherst, WI. Cost $400.

October 22 — Residential Solar Energy — Doug Steege, Altech Energy, Madison, WI. Workshop located in Madison, WI. Cost $100.

November 11, 12 & 13 — Introduction To Renewables — Mick Wurl-Koth, Solar Spectrum, Tomahawk, WI. Workshop located at Treehaven Learning Center, Tomahawk, WI. Cost $250.

For more information:

Midwest
Renewable Energy Association
P.O. Box 249, Amherst, WI 54406
(715) 824-5166

Swords into Plowshares

Michael Welch

For almost 50 years, the Nevada Test Site (NTS) has been host to our country's nuclear weapons test facility. Though an excellent solar site, the Test Site has held a dark and gloomy pall, even though for many years exploding nuclear weapons produced blinding, bright flashes.

In March, the U.S. Department of Energy (DOE) announced a study that concludes that the 1,350 square mile NTS could host a selection of solar electricity generating facilities to be owned by private companies. The study further suggests that private industry might be attracted to the site if the federal government provided land, power line improvements, and other support. The funds for the study were part of the Defense Reauthorization Act of 1992. This project appeals to many as an appropriate way to create jobs to replace those lost to the declining war industry.

Now that the study is completed, a task force called the Solar Enterprise Zone Working Group, is being set up to look into land and site preparation, infrastructure improvements, and environmental issues. The task force will be made up of a DOE representative, Nevada regulatory delegates, representatives of Nevada's Congressional delegation, the NTS Contractors Association, various solar industry reps, and others. They will meet four times over the rest of this year. This project has gained the attention of the Clinton Administration, which was planning to send Vice President Gore to address the first task force meeting to help emphasize its importance. Eventually, the task force will be looking for public input on these potential projects. For more information on public participation, call the DOE at 702-295-3521.

Conjecture has it that a 600 megaWatt power plant will be built over a six to eight year period as a start-up or demonstration project. Seems to me, though, that even with things moving at the normal bureaucratic snail's pace, they should be able to do better than six to eight years. I hope that the DOE really puts the pedal to the metal on this one. With essentially free sites and support offered, private industry should be clamoring to get something built and online at the Test Site.

Roy McAllister, President of the American Hydrogen Association, has been participating in the efforts to make this project a reality. Roy's vision of this project includes using NTS (and other sites) as "Renewable Resource Parks". They could use all available off-load power from the site to make hydrogen gas, pipe and store the hydrogen in depleted fossil fuel fields and other geological formations, then use the gas to generate electricity at night, during peak load times and during adverse weather conditions. The gas could also be safely used for domestic purposes.

I hope the project will lead to the building of many power plants at the Test Site. According to Nevada Senator Richard Bryan, using about 7% of the Test Site land area could produce as much as 10,000 megaWatts of electricity — enough to replace ten large coal or nuclear-fired power plants.

NATAS + CAREIRS = EREC (new math, of course)

In Power Politics, HP#32, I reported on two outstanding government projects, the National Appropriate Technology Assistance Service and the Conservation and Renewable Energy Inquiry and Referral service. Things have been a little up in the air about these two organizations, but the good news is that they have survived and combined into the Energy Efficiency and Renewable Energy Clearinghouse (EREC).

EREC is operated by a contractor under NREL, providing related info and technical assistance to anyone. Their number is 800-523-2929. The services cost nothing, and include everything from databases, publications, and bibliographies to educational materials and technical and engineering advice. Don't lose that phone number, you will need it someday.

A Bigger Piece of the Pie for Renewables

Funding for renewables and energy efficiency took a bigger part of the energy dollars pie this year, and Clinton's 1995 proposed budget includes a further 33% increase. But, there is still a long way to go.

Indiana Representative Phil Sharp has introduced House Concurrent Resolution 188, which calls for a major change in U.S. energy priorities, and recommends transferring $1 billion from oil, gas, and nuke programs to energy efficiency and renewables programs. The resolution also outlines the dual goals of increasing U.S. energy efficiency by 30% and renewables usage by 20% by the year 2010.

While this bill doesn't have much teeth, it is important from the standpoint of giving more power to congressional renewables advocates as they work on the energy budget for next year. So, please write your Congressperson as soon as possible, and ask them to cosponsor the Sharp Resolution, House Concurrent Resolution 188.

Zero-Emission Vehicle Laws in Jeopardy

California Air Resources Board (CARB) mandates require that 2% of new car sales in California be zero-emission vehicles (ZEV) by 1998, rising to 10% by 2003. At this time, New York, Massachusetts, and Maine have also adopted the California rules with many more states interested in following suit.

This is great news, except that the U.S.'s Big Three auto makers, possibly the most powerful corporations in America, don't like these rules one bit (do I hear violins in the background?). The reasons why are easy to surmise, but the auto makers claim they will lose money on early sales of these vehicles, without a way to recoup these losses later on as the electric vehicle (EV) industry becomes more developed. Following California's laws, according to the Big Three, will be hard enough, but with expected copycat regulations proliferating throughout the U.S., the auto manufacturers say they will have to produce tens of thousands of EV's at a loss, instead of just a few thousand to satisfy California's requirements.

As you can imagine, the Big Three have pulled out all stops in trying to get the CARB mandates overturned. All have hired lobbyists to cover the Sacramento legislature, Ford was granted personal audience with California Governor Pete Wilson and plans to begin increasing political donations in California, and General Motors is leading the efforts to fight the spread of the rules to other states. The prevailing tactic seems to be to convince regulators that clean-air goals could be better met by natural gas and hybrid (internal-combustion/electric) vehicles.

Past history has shown the car manufacturers to be pretty effective at using their resources to remove regulations that may increase their manufacturing costs or point the safety finger at their products. Already, CARB lost its chairperson that was steadfastly promoting the rules. Some say that her resignation was forced as a result of Governor Wilson's pro-business attempts to gut environmental regulation, but even her replacement seems to be interested in sticking to the ZEV rules. Some California legislators have introduced legislation to gut the CARB rules, but it is seems unlikely that they will pass.

Hope prevails. Nationwide, formidable proponents are lining up for this fight. Environmental groups and consumer groups, are siding with CARB, as well as utilities and businesses that see financial opportunities opening up along with the increased demand for EV's.

The fight has been going on for a while, and the rules remain in place. Most regulators are sticking by the rule, but 1994 is the key year. The regs call for review in September, and again in 1996, but the September review is important since auto manufacturers typically have a three year lead time to design and produce a car. This means this must be settled soon, so that 1995 can be spent gearing up for the 1998 deadline.

You can help with this landmark effort to bring EV's into the mainstream. If you live in California, write your state legislators and governor asking them to uphold the CARB rules as they relate to ZEV's. If you live outside of California, write your own legislators asking them to adopt California's regulations for your own state. This is one instance where citizen input may be able to tip the balance between opposing lobbyists, businesses, and groups.

Access

Author: Michael Welch, c/o Redwood Alliance, PO Box 293 Arcata, CA 95521 • 707-822-7884 voice • 707-822-8640 computer BBS

Different Strokes

Therese Peffer

So you don't want to use one-use throw away batteries for your Walkman. Or maybe you've been using rechargeable cells for a while, but they don't quite work as you expected. Perhaps you're new to this renewable energy stuff and are just plain curious about batteries — solar charging AA cells is a great place to begin. Which rechargeable cell is right for you?

Back in *HP*#38, I ran six brands of nickel cadmium AA cells through several discharges. And I received comments from a few readers: what about nickel metal hydride cells? How about those new rechargeable cells by Rayovac, the Renewal cells? Why doesn't my flashlight shine as bright with nickel cadmium cells as it does with Duracells? Good questions! I got to work.

What are we powering?

First of all, what are we asking these cells to do? Richard tells me that you can start an (already warm) car with ten nickel cadmium D cells in series. That's 4 Amp-hours at 12 Volts. You can imagine the high current drain (about 200 Amperes!) on these cells. Of course, the typical use of D cells is not starting cars, but the point is you'll make better use of your cells if you know more about the load they're powering.

Battery-powered loads or appliances — flashlights, radios, pencil sharpeners — take two or more cells. These cells will last minutes to months of use, depending on the appliance, how it is used, and cell capacity. Each appliance has its own current draw and voltage cutoff point. You might find out how much that stereo draws by reading the label on the back or scouring the literature. Or you may already know your high-drain appliances by how often you change the battery! Cutoff voltage refers to the voltage at which that flashlight dims or radio falters — the appliance no longer works. Stephen A. Booth in *Popular Mechanics* (Jan 1994) listed 12 devices — flashlights, stereos, radios, a remote control — and their cutoff voltages. Why is cutoff voltage so important? As a battery is discharged, its voltage drops. Two AA cells at 1.1 Volts each could not power a pencil sharpener with a cutoff voltage of 2.4 Volts. But theywould run that radio with a cutoff voltage of 1.6 Volts.

Whether the device is used continuously or not affects how long that battery will last. You might slap some cells in your Walkman and listen until the cells die. Or you might listen for an hour, turn it off for five hours, and listen again for an hour, and so on. If the cells have a chance to "recover", they will last longer.

The Rating Game

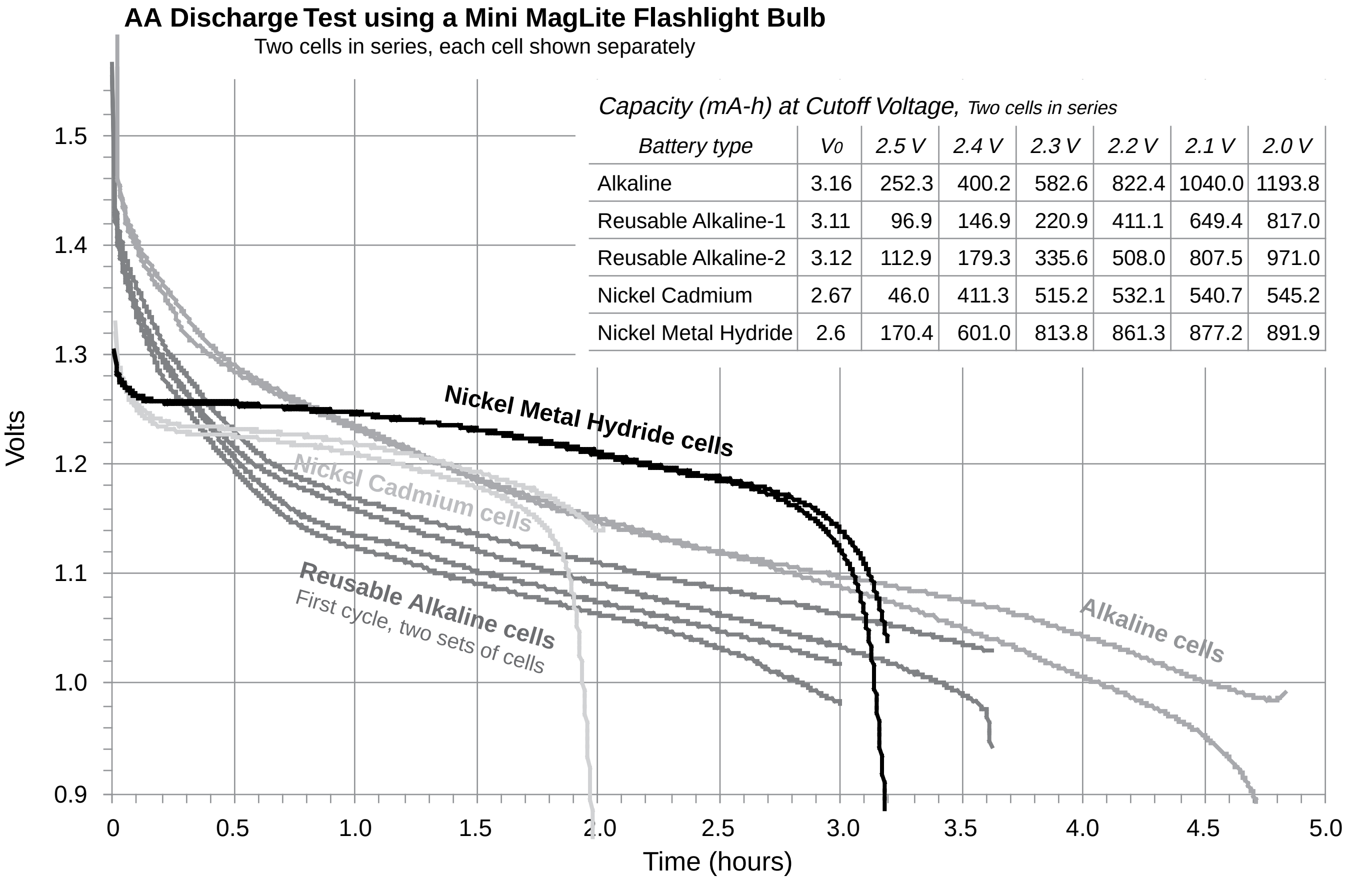
To compare batteries, we must compare the capacity, the rate of discharge, and the voltage drop over discharge. And we soon discover that manufacturers rate their cells differently — there's no standard.

I compared the performance of nickel cadmium, nickel metal hydride, and reusable alkaline AA cells with a non-rechargeable throw-away alkaline cell. Batteries are rated in terms of their capacity and discharge rate. For example, Panasonic tells me that the Panasonic nickel cadmium cells I used have a capacity of 600 milliAmpere-hours (mA-h) when discharged at a C/5 rate, or totally discharged in five hours.

I know, I know. A lot of numbers. Think of the capacity as a bucket of water. A medium hole in the bottom of the bucket is like a C/5 rate — the bucket (battery) is empty in five hours. The capacity of a battery depends on the C rate. A big hole in the bucket would empty the bucket in an hour (C/1 rate); with a battery, you get less capacity (water) at this fast rate than at a C/5 rate. On the other hand, a small hole in the bucket might stretch that water for 50 hours (a C/50 rate); a battery drained at a C/50 rate would have more capacity than at a C/5 rate. A C rate is used to compare different batteries. For example, the Maxell nickel metal hydride AA cells are rated at 1100 mA-h at a C/5 rate. Since both the nickel cadmium and nickel metal hydride cells are rated at the same rate, I can compare their capacity.

However, the Duracell alkaline AA cell is rated 2450 mA-h with a 24 Ω load (or 50 milliAmp current draw) to 0.8 Volts (I'll leave temperature out of this). Ack, no C rate, but I can figure it out. I know the capacity (C = 2450 mA-h) and the rate of discharge (A = 50 mA), so I divide to get the hours (2450/50 = 49). I get a C/49 rate, that is, the cell will be totally discharged in 49 hours if discharged at 50 milliAmps. But to compare the Duracell with the nickel cadmium cell, I need to know the capacity at a C/5 rate!

What about those new rechargeable alkaline cells, the Renewal cells? The literature from Renewal rates the AA cell at 1500 mA-h at a 3.9 Ω discharge to 0.9 Volts for the first cycle. The capacity drops with each cycle.



Capacity (mA-h) at Cutoff Voltage, Two cells in series

Battery type	V_0	*2.5 V*	*2.4 V*	*2.3 V*	*2.2 V*	*2.1 V*	*2.0 V*
Alkaline	3.16	252.3	400.2	582.6	822.4	1040.0	1193.8
Reusable Alkaline-1	3.11	96.9	146.9	220.9	411.1	649.4	817.0
Reusable Alkaline-2	3.12	112.9	179.3	335.6	508.0	807.5	971.0
Nickel Cadmium	2.67	46.0	411.3	515.2	532.1	540.7	545.2
Nickel Metal Hydride	2.6	170.4	601.0	813.8	861.3	877.2	891.9

The folks at Rayovac told me that this capacity does not reflect a continuous discharge. The capacity would be 1100 mA-h for a continuous discharge to 0.9 Volts (at a C/3.6 rate). Again that's just the first cycle. These cells should deliver 16.5 Amp-hours over 25 cycles.

Voltage

All these numbers — are you screaming yet? The best is yet to come! I was curious about the voltage of each battery under discharge. I've heard that nickel cadmium cells don't work as well as alkaline cells in some appliances because the voltage is lower than alkaline cells. I've heard that appliances using nickel cadmium cells just suddenly stop when the cells are discharged. With alkalines the appliance gradually slows down. The voltage curve will affect the capacity of the cell at the cutoff voltage of the appliance; this shows what cells would be best for which device.

The Test

To compare these four batteries, I used two cells of each type to power the same load, a Mini MagLite flashlight bulb. I discharged the cells continuously, down to 2.0 Volts. (The light starts to dim earlier than this). I used our Remote Measurement Systems analog to digital datalogger with our PowerBook 160 computer (see *HP*#38 for the setup). The Duracell alkaline cells and Renewal reusable alkalines were tested right out of the packaging. The nickel cadmium and nickel metal hydride cells need charging — they like a few cycles before use. The Panasonic nickel cadmium cells had about 20 charge/discharge cycles and the Maxell nickel metal hydride cells had about six cycles before the test.

Take a look at the test results. The table above shows the voltage curves of each cell over the discharge. The nickel cadmium cells and nickel metal hydride cells have a similar voltage curve. They start at a lower voltage than the alkalines and have a flat voltage plateau before they dive down at about 1.1 Volts. The alkalines start out at about 1.5 Volts (see initial voltage, V_0), quickly come down to 1.4 Volts, and then gradually fall to 0.8 Volts over the discharge. The alkalines drew slightly less current on average than the nickel cells. (273 mA and 271 mA for the Renewals and Duracells respectively, 287 mA and 284 mA for the Panasonics and Maxells respectively). Maybe this is due to the higher sustained voltage of the nickel-type cells.

What may seem like a bunch of squiggly lines on a graph can actually tell us what to expect from these batteries and how to use them wisely. Suddenly, cutoff voltage should have new meaning. The table shows the capacity of each type of battery at various cutoff points. I know, I know — more numbers. But try an example: say your flashlight takes two AA cells and is

really bright at 2.5 Volts and above. Look down the 2.5 Volt column and see which battery has the highest capacity. Those alkalines look pretty good. But say your two-AA radio poops out at 2.2 Volts. Now those nickel-type cells look good.

When you take the cells out of that flashlight when it dims, they are only partially discharged. Think of all those people using Duracells and just throwing the cells away at this point. WAAH! Not only are those one-use cells a waste of materials, but only one-third of their energy was used! What a waste!

The Bottom Line

So what does it all mean? The nickel metal hydrides are my current favorite. Pros? High capacity, high voltage over discharge, will last hundreds of cycles, no memory effect, and can withstand high discharge rates (3 A). Cons? Currently these cells are fairly expensive ($5–8 each), may not fit some devices, and have a high self discharge rate (a fully charged cell, after 30 days storage at 20°C, will deliver 70% of capacity). I use a homebrew charger and a timer to charge these cells; I don't know of a commercially made charger.

I still like my nickel cadmium cells. Pros: cheaper than nickel metal hydrides ($2.50–$3 each), will last hundreds of cycles, chargers available. Cons: so-called memory effect (if you partially discharge these cells a dozen times in a row, they will "remember" a lower capacity), fair discharge rate (80% capacity after one month, 55% after six months (but 80% after six months if stored at 32°F!).

The Renewal cells? If you're not happy with nickel type cells because they initially have a lower voltage, use the Renewal cells. Note that the voltage of the alkalines soon drops below that of the nickel cells. Renewals love this type of service — after a partial discharge, they go back in the charger — and should last at least 25 cycles (see sidebar). Since the nickel-types cells self-discharge, use Renewals for that emergency flashlight that sits around for years until you need it (96% after one year). Otherwise, use nickel cadmium cells and wait for Maxell to sell AA cells to the public!

A note on Nickel Metal Hydride cells

I know six companies that manufacture nickel metal hydride cells: Harding, Eveready, Sanyo, Panasonic, Varta, and Maxell/Hitachi. Unfortunately, most of these companies sell directly to OEMs, not to Joe Public. When I tried to get a couple of cells just for this test, I was told few samples are available because these cells are in such demand. Thanks to George Patterson, I obtained two cells from Maxell. You may see some other brands on the market now — buyer beware in terms of quality. One of the cells I bought from a mail order catalog was junk (internal short circuit).

Charging and Changing

Three years ago I moved from the city to live in the country here at Home Power. And now, with mixed feelings, I'm moving back, this time to Eugene, Oregon. Richard and Karen and you readers that make up Home Power have taught me a great deal about renewable energy. I'm going back to school to learn about architecture so I can incorporate solar electricity and energy efficiency with passive solar design. Thank you, readers, for the letters and conversations of constant inspiration. And thank you Richard and Karen who taught me everything I know about living in the country, electronics, puddies, and running a business with open hearts, minds, and hands. Happy charging!

Access

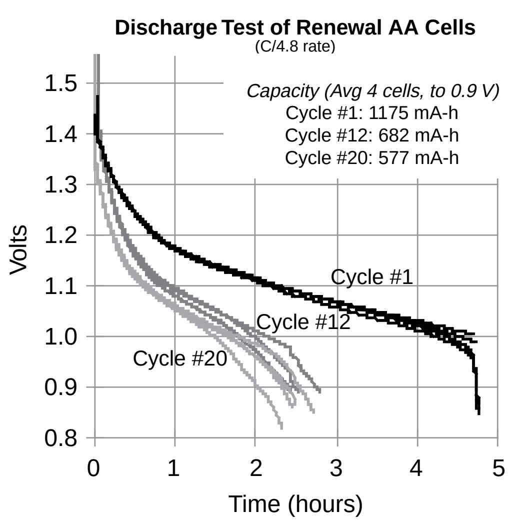
Therese Peffer, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179

How 'bout those Renewals?

I've heard much interest in these reusable alkaline cells from Rayovac. See graph/table for my experience with four AA Renewal cells. I saw over 1100 milliAmp-hours (mA-h) after the first discharge to 0.9 Volts (246 mA average current, a C/4.5 rate). By the 12th discharge, the capacity was about 682 mA-h. After 20 cycles, the capacity was 577 mA-h.

I charged the cells in the wall unit Power Station recommended to charge these cells. When cells are discharged to 0.9 Volts, the charger takes 6–8 hours to charge the cells. Each cell is pulse-charged separately, with its own red light that turns off after the cell is charged. I discovered that after the lights go out, the charger continues to "trickle" charge the cells — about 20 mA current. Pretty nice charger! I want one for nickel cadmium and nickel metal hydride cells.

Conclusion? Buy these if low self-discharge and slightly higher initial voltage are important to you. Otherwise, nickel metal hydride cells have more capacity (except for the first cycle) and last hundreds of cycles.



Good Books

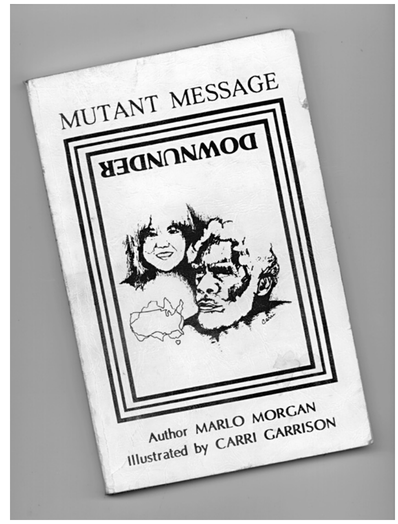
Mutant Message Downunder

by Marlo Morgan

Reviewed by Kathleen Jarschke-Schultze

Mutant Message Downunder is probably the most unusual, most fascinating book I have ever read. What has it got to do with Renewable Energy? Nothing. In fact it is about not impacting the environment at all. The Aborigines of Australia have lived there for 50,000 years and have not changed their environment at all. This is the story of a 50 year old American woman who, in 1990, was chosen by a tribe of 62 Aborigines to go Walkabout with them for three months in the Outback. They felt she was the messenger they had been waiting for to carry their truths back to the rest of the world.

While reading the book has not caused me to give up my worldly possessions, it has made me realize just what a conspicuous consumer I am. I feel the need to pass the message on to other people. I have ordered two books because we have to return the one loaned to us and I have friends that I want to share this story with. *Mutant Message Downunder* is a paperback book of 165 pages. The cost is $12 which includes postage.



Access
MM Co., PO Box 100, Lees Summit, MO 64063 • 816-246-6365

IPP

Don Loweburg & Bob-O Schultze

The Independent Photovoltaic Power Providers (IPPP) is now the Independent Power Providers (IPP). We've dropped the word photovoltaic to encourage *all* Independent Power Providers to join together under one banner.

If we're to guide our own destiny and that of those to come after us into the Renewable Age, we need the strength of all the Independents whether they provide power by wind, hydro, co-generation, or solar thermal. And it doesn't matter whether you're "in the biz" or whether you are providing power for the utilities, your neighborhood or just yourself. We all need a strong voice that says, "Hey! We're here, we've *been* here, we've helped pioneer this thing and there's no way we're going to let the big monopolies own the sun or control the ways and means to independent power production."

The feedback we've received to open IPP to all Renewable providers has been incredible. Independents everywhere are paying attention and can see the big utilities maneuvering for control. At the same time, nobody has any illusions about the existing solar organizations. One look at the membership list is enough. Manufacturers, utilities, government organizations aplenty and damn few Independents. So here we go. All aboard?

California News:
On April 6 the California Public Utilities Commission (CPUC) approved Southern California Edison's off grid photovoltaic tariff. This is supposedly an "experimental" three year program and was opposed by IPP. Though our efforts did not stop the program, we feel encouraged because many changes were required by the CPUC and SCE must now refile for final program approval. These changes strengthen compliance and monitoring issues and were required as a result of the protest and intervention of IPP and its supporters. Given the vast resources of SCE as opposed to the "Mom & Pop Solar" nature of IPP members, this is a tremendous victory.

The CPUC, while allowing the program, will be watching closely to ensure that Edison's program lives up to its promises: to strengthen the PV industry, to not harm existing system providers and benefit the ratepayer. As you already know, IPP believes these promises will not be kept. We will be keeping a close watch over their program as it's implemented!

A big change is in the wind for utilities in California. According to the latest policy statement from the CPUC, power generation will be essentially deregulated within the next eight years. By 2002 all users will be able to choose from whom they buy their power. The term "direct access" was used to describe this new policy. IPP believes these changes may radically affect the utility role in the PV market, favoring the decentralized, user owned model over the monopolistic centralized utility system now in place.

What IPP Stands For
What does IPP stand for? Fundamentally we support distributed user owned power generation. Power can take the form of solar thermal, hydro, wind, and photovoltaic. This matrix of on-site generated power has begun with the off-grid market and will spread to the grid. This will be the new paradigm of power generation for the 21st century. The benefits we see are many. There will be a huge reduction of emissions, and the emergence of healthy, diverse and competitive manufacturing companiesjobs created servicing and installing these systems, .

Our program at this time is to discourage utilities from entering the already cost effective off-grid market, encourage the user-owned PV grid connected market by insisting on customer net billing, and help develop financing opportunities for PV system purchases.

Whether you are now a provider or soon to be, an RE dealer, installer contractor, manufacturer or anyone who shares this vision, we invite you to join IPP. A phone call or letter is all it takes.

The following states have utility collaboratives working at this time that promote the interests of over 80 utilities nation wide to enter the PV market. We need people who share the IPP vision to get involved. The states are: Arizona, California, Colorado, Delaware, Hawaii, Idaho, Maryland, Massachusetts, Minnesota, New York, North Carolina, Ohio, Texas, and Wisconsin.

Call or write for contacts in your state. IPP can coordinate but the energy must come at the local level. What we do (or don't do) today will affect who controls the power of Renewable Energy for decades.

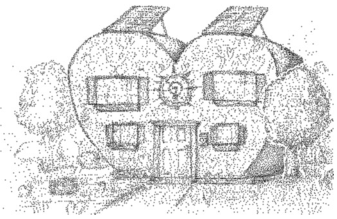
Access
National: Bob-O Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 916-475-3401

California: Don Loweburg, Offline Independent Energy Systems, PO Box 231, North Fork, CA 93643 • 209-877-7080

Home

&

Heart



Kathleen Jarschke-Schultze

With the days getting longer and warmer my thoughts turn to outdoor activities like gardening, and solar cooking. Anyone can cook with the sun. All you need is a solar cooker. There are many different types — home-made and production models. Okay, you've got the solar cooker, now what?

Solar Cooking Hints

Always use lids on your pots and pans to avoid condensation which limits the sun's rays. Using a thermal pane on your oven will reduce condensation also.

Rule of thumb: when using your own recipes, figure two times the regular cooking time. Of course, occasional clouds will lengthen cooking times.

If you will not be around to tend your oven, set it to focus on the sun between the hours of noon to 2:00 PM. The food will be cooked and then kept warm as the sun moves out of focus.

Solar cooked food never gets burned onto pots. It heats evenly, without hot spots. It is hard to overcook a sun cooked meal. Add cheese to the top of casseroles after you remove them from your cooker. Replace the lid until cheese melts.

When opening oven keep your face back and use potholders. Steam and heat could cause injury.

Converting Family Favorites

Any recipe you cook in a regular oven at 350°F for 30 minutes or more can be used in a solar cooker with no changes to the ingredients. The cooking time will be lengthened. How much longer depends on the brightness and length of your available sunlight. Here are some of my favorites:

Solar Cooking Recipes

Whole Cheesy Tomatoes

whole tomatoes
bread (best if homemade)
cheese cubes or spread (Mozzarella is good)
Fresh or dried Basil, Oregano and Garlic
salt and pepper

Place whole tomatoes in greased ramekins and cut through into four sections. Add bread that has been spread with cheese and torn into pieces or alternate bread pieces and cheese cubes. Sprinkle with seasonings and a dash of salt and pepper. Cover and bake about 45 minutes.

(It's easy to cook to individual tastes in vegetables by using ramekins. My favorites are the small covered Visionware® dishes. They have flat tops so they are stackable, and are clear amber so you can see the food cooking.) *Sis Mueller*

Auntie Dot's Enchilada Pie

1 large can enchilada sauce
1 package. flour tortillas
1/2 pound cheddar cheese, shredded
1/2 pound Monterey jack, shredded
2 large onions, chopped and cooked
2 cans whole olives, halved

In Dutch oven, dark casserole dish, or Visionware dish with lid, layer sauce first, then tortillas, then onions and cheese, then sauce, then tortillas and so on until the last layer, then tortillas, sauce, then onions and olives. Bake in solar cooker for about three hours or until heated and bubbly. Remove from oven. Add last of cheese. Let sit 5–10 minutes before serving. Hamburger and extra tomato sauce optional. *Dorothy Jarschke*

Vietnamese Chicken

Put 1 stick of butter in a covered Dutch oven, place in solar oven and focus oven. As the butter is melting get together about 8 chicken legs, 4 medium cloves of garlic, chopped, and 2 medium onions, also chopped. Add to butter in heated pan and stir to coat. Refocus oven. In one hour stir ingredients in pan and refocus oven again. In one more hour chicken legs should be fully cooked. Add 2 Tablespoons soy sauce. Serve over plain rice using drippings like gravy.

If you are going to be gone or don't want to refocus oven every hour just place melted butter and other ingredients in pan, stir to coat and focus oven to get sun at premium time (noon to 2:00 PM) and it will be done when you return. *June Jarschke*

Sunny Scalloped Potatoes

6–8 medium sized potatoes, sliced
1/4 cup chopped onion
1/2 cup salted sunflower kernels
2 Tablespoons flour
3 Tablespoons sunflower margarine
1/4 teaspoon paprika
1 1/4 teaspoon salt
1 1/4 cup milk, heated
1/2 cup grated cheddar cheese

Alternate layers of potatoes with onion and sunflower kernels, sprinkling each layer with flour and dotting with margarine. Add paprika and salt to milk and pour over potatoes. Bake, covered, in solar cooker for three hours or until done. Just as you take it out of the solar cooker sprinkle with cheese. Cover until cheese is melted. Adapted from Alice Scanson, owner and chef of the Sunflower Cafe in Grace City, North Dakota.

Carrot Cake

Cream together:
3/4 cup honey
1/4 cup molasses
1/4 cup each powdered milk and whey

Add to the above:
1 cup oil
4 eggs
2 cups shredded carrots
1 cup chopped walnuts

Mix together, then add to bowl:
2 3/4 cup wheat flour
2 teaspoon cinnamon
1 teaspoon each baking soda, baking powder, nutmeg
1/4 teaspoon salt

Pour into 13” x 9” pan or two loaf pans. Bake about two hours or until toothpick comes out clean when inserted in center. In conventional oven bake at 350° for 45 minutes. *Katcha Sanderson*

Conclusion

Surprise your family. Make them a sun cooked meal. Heck, make lots of them. Once you start you’ll be hooked. My first sun cooker cost $3.57 to make using the Heaven’s Flame guidebook. I still have that cooker and still use it.

Access

Author: Kathleen Jarschke-Schultze keeps on cooking in her herb garden in northern-most California, c/o Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-0830

HAPPENINGS

INTERNATIONAL

COSTA RICA

2nd Annual World Conference Solar Cooking Use and Technology, July 12–15 1994, Universidad Nacional, San Jose, Costa Rica. Contact Solar Cookers International, 1724 11th St, Sacramento, CA 95814, 916-444-6616, fax 916-447-8689.

FRANCE

The European Conference on Energy Performance and Indoor Climate in Buildings will be held Nov. 24–26 1994 in Lyons, France. Its aims are to discuss the results from research and development in solar energy applications and the rational energy use in buildings, to confront the views and needs of industry and professionals, to inform the European building community on the latest developments in the research and application of new building products and evaluation of tools and to discuss the possibilities for standardization of assessment methods and energy performance requirements on a European-wide level. The oral sessions will be in English and French. For more information contact, Ecole Nationale des Travaux Publics de L'Etat, Rue Maurice Audin, 69518 Vaulx en Cedex, phone 33-72047070, fax 33-72046254, telex ENTPE 370511F

GERMANY

The 27th Annual ISATA International Dedicated Conference on Electric, Hybrid & Alternative Fuel Vehicles will be held October 31–November 1 1994 in Aachen, Germany. The conference will focus on the most pressing questions in the world of Electric, Hybrid and Alternative Fuel Vehicles. For more information contact ISATA Secretariat, 42 LLoyd Park Ave, Croydon, CR0 5SB, England, 081-681-3069 Fax 081-686-1490

NATIONAL

Don't miss the fifth annual Midwest Renewable Energy Fair, June 17–19, 1994 at the Portage County Fairgrounds, in Amherst, Wisconsin. It includes speakers and workshops for adults and kids on solar, photovoltaics, wind, microhydro, wood, and energy conservation; vendor display booths; an alternative vehicle showcase; teacher curriculum workshops; entertainment and food. For further information, contact Midwest Renewable Energy Assn, POB 249, Amherst, WI 54406 • 715-824-5166

ARIZONA

World Unity Festival, August 22–28, 1994, Flagstaff. The Festival celebrates global oneness, generates environmental awareness, shares cultural wisdom and honors the Earth's diversity. Contact: Quetzalcoatl Productions, 4 San Francisco St #438, Flagstaff, AZ 86001 • 602-773-9669

ARKANSAS

Meadowcreek offers a seminar in basic photovoltaics on July 16, 1994 from 10 AM to 4 PM. The sessions provide information on designing and installing your own solar electric system. The cost is $10 and includes a detailed design manual. If you would like to become more energy independent or are simply interested in solar energy, contact Meadowcreek, PO Box 100, Fox, AR 72051, 501-363-4500 for more information.

CALIFORNIA

The 4th Solar Energy Expo & Rally (SEER), July 15–17, 1994 at the Redwood Empire Fairgrounds, 1055 N State St, Ukiah, CA. For information: Janet Orth, 733 S Main St #234, Willits, CA 95490 • 707-459-1256

Siemens Solar Industries is offering its 1994 five day Photovoltaic Technology and System Design Training Course. Learning begins by purchasing the two volume set of Training Manual and Technical Appendix for $175. The fee includes the 30 minute videotape "The World of Solar Electricity". Step two is a five day training class. Classes will be held July 18–22 (a special advanced course) & September 19–23 at the Siemens Solar Training Center, Camarillo, CA. The training class, including the two set manual & video is $1500 (food and lodging not included). The course offers experimentation with inverters, controllers, batteries, modules, trackers and loads. The "final exam" is a full system design. Contact the Training Department of Siemens Solar Industries for a Course Information Package and application form. Call Cindy Vernon • 805-388-6568 • fax 805-388-6395.

Solar 94: Golden Opportunities for Solar Prosperity, June 25–30, 1994, San Jose, CA features the 23rd American Solar Energy Society Annual Conference and the 19th National Passive Solar Conference. For more information contact American Solar Energy Society, 2400 Central Ave. G-1, Boulder, CO 80301 • 303-443-3130 • fax 303-443-3212.

COLORADO

Solar Energy International (SEI) is offering workshops on the practical use of solar, wind, and water power. The 1994 Renewable Energy Education Program (REEP) features one and two week workshops: Solar Home Design Principles, Alternative Building Technologies & Passive Solar, Women's Basic Carpentry, Solar Water Pumping, PV Design & Installation, Advanced PV, Solar Cooking, Drying & Water Distilling, micro-hydroelectric systems, alternative transportation & EV Conversions, Hydrogen Energy. Guest speakers and professional instructors will teach the design of state-of-the-art solar homes that are self-reliant, energy efficient, healthy to live in, and earth-friendly. Participants will learn the knowledge and skills to build energy independent homes with solar, wind, and water power. The series is for owner-builders, industry technicians, business owners, career seekers, and those working in developing countries. The workshops may be taken individually or as part of a program. The cost is $400 per week. Scholarships and work/study programs are available on a limited basis. Contact: Solar Energy International, PO Box 715, Carbondale, CO 81623-0715 or call 303-963-8855.

The Crestone Energy Fair will be September 10–11, 1994. The usual fun — great solar-powered music, delicious solar baked food, and the gathering of the solar tribe for council. Contact Kenny Dessain, Turtle Island Peace Camp, PO Box 222, Crestone, CO 81131.

The 3rd Annual Boulder "New Renaissance" Festival will be held Sept. 3–5, 1994 in Boulder, Colorado. A future oriented community event whose focus is on creativity, art, education , health and wellness, and a strong emphasis on the environment and appropriate technology. This year's festival will spotlight technology for building a sustainable society with expanded emphasis on renewable energy. TIMEWEAVE, the educational non-profit group producing the festival, is working with Citizens for Clean Energy to design the Solar Electric Carnival, an interactive educational exposition of renewable energy technology. After the 1994 Festival this display will become a mobile educational exhibit, available for schools and other public events. Planned events also include media and policy maker's days for EVs, an electrathon race, a 10K WalkAbout# and a hybrid electric/HPV challenge. The Festival is seeking participation from individuals, groups and industry. To participate or exhibit, contact Steve Clark, TIMEWEAVE/BNRF '94, PO Box 348, Boulder, CO 80306-0348 • 303-939-8463

"Solar Systems Made Simple" June 25, Canon City, CO is a one day class designed for those living in a home powered by solar electricity, or those who plan to have their own system. The class covers all of the basics starting with basic electric terms and covering system design and sizing, and what appliances to use in an off-grid home.The day ends reviewing how to maintain and troubleshoot your system. The class takes a "Whole Home Approach", from space heating to water pumping and designing a system that will fit your life!. Cost is $30 ($10 pre-registration deposit required), $45 for two people from same family. Classes run from 9 AM to 4 AM. 800-784-3603

The Freedom Festival, Sunday July 3, 1994, is an event featuring great music and entertainment as well as providing an informal venue for inspirational, educational, alternative energy exhibits (solar, bio-mass, photovoltaics, new construction materials, etc.), alternative health care and healing arts, arts & crafts, good food, featured speakers, fun and educational activities for children and adults of all ages. The event will be located along the grassy banks of the Colorado & Roaring Forks Rivers at Two Rivers Park in Glenwood Springs, CO For more information contact: Freedom Festival PO Box 1326, Carbondale, CO 81623, 303-963-2285

FLORIDA

Hydrogen '94, June 20–24 1994. 10th World Hydrogen Energy Conference & Exhibition, Cocoa Beach, FL. Contact Florida Solar Energy Center, 300 State Rd 401, Cape Canaveral, FL 32920-4099 • 407-783-0300, fax 407-783-2571.

The 1994 ARRL 19th Annual Amateur Radio & Computer Convention will be held November 19 & 20, 1994 in Tampa, Florida. For more information contact FL Gulf Coast Amateur Radio Council, PO Box 2423, Clearwater, FL 34617-2423 or call Bill Smith 813-837-4533.

IDAHO

Backwoods Solar Electric Systems will hold two Saturday workshops (June 11 & September 3, 1994) on photovoltaic theory, equipment and installation. Limited to ten people. Non-refundable, pre-registration of $40 covers class, lunch and text book, or $30 per person for couples sharing the book. Contact Backwoods Solar Electric, 8530 Rapid Lightning Creek RD, Sandpoint, ID 83864, 208-263-4290.

IOWA

The Third Annual Iowa Renewable Energy Expo & Alternative Fuel Vehicle Showcase will be held September 10–11, 1994 at Hawkeye Downs,

Cedar Rapids, IA. The Expo will feature: Entertainment, Speakers, Kids Activities, Demonstrations, Workshops & Displays of small-scale & utility wind systems; active solar heating; PV systems & water pumping; energy & sustainable agriculture; conservation; energy efficient architecture; hydrogen, soy diesel, natural gas, solar powered & conversion vehicles; basic electric, batteries, inverters; utility issues and more. Contact Iowa Renewable Energy Assn., 611 Second St SE, Dyersville IA 52040 • 319-875-8772 or Stan Eilers, 319-365-7314 or Tom Deves, 319-556-4765.

MASSACHUSETTS

11th Annual Quality Building Conference '94 — Making Sustainable Building Standard Practice: November 11–12, 1994 in Springfield. Expert builders will present practical, cost effective applications of the latest advances in energy efficient, sustainable design and construction, indoor air quality, and building science. QBC'94 will take a comprehensive look at the people, economics and practices which are changing the way we think about and construct buildings. Workshops, technical presentations, demonstrations and a design competition will underscore the close connections between energy efficiency, sound business growth and environmental responsibility. In depth workshops will feature the Energy Crafted Home, Waste Reduction and Recycling and other topics. For more information contact NESEA, 23 Ames St, Greenfield, MA 01301 • 413-774-6051 • fax 413-774-6053

MICHIGAN

The 4th Annual Great Lakes Renewable Energy Fair will be held August 6 & 7, 1994 in Traverse City. Demonstrations, workshops, speakers, display booths, children's activities, food, solar panels, windmills, electric cars & boats, a bus tour of local RE homes & biomass will be covered. For more information contact GLREA, 11059 Bright Rd, Maple City, MI 49664, 616-228-7159

NEW MEXICO

A workshop on PV systems is being presented on July 13 & 14, 1994 by Sandia National Laboratories' Photovoltaic Design Assistance Center.The two day program will cover: technology developments; utility field experience; design, installation & OEM; hybrid systems; large DoD system designs. The workshop is intended for members of the PV and supporting industries, government agencies and utility personnel. Participants will receive: a compilation of material presented during the workshop and technical handouts on a number of subjects including batteries, charge controllers, hybrids and other fielded applications. There is a $75 attendance fee. For more information on this workshop contact Mike Thomas, 505-844-1584. For pre-registration (by June 24,1994) contact Peggy Valencia, 505-844-3698, Fax 505-844-2890.

NEW YORK

June 11–12, 1994, Here Comes the Sun! The Northeast's Alternative Energy Fair, to be held at the Rochester Institute of Technology in Rochester. Brought to you by the Center for Environmental Information, the Fair is designed to introduce the public to a wide range of contemporary alternative energy technologies. Featured at the Fair will be workshops, exhibits, vendors booths, speakers, tours and the regional Jr Solar Sprint model race car competition. For more information, please call 716-262-2870.

The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings, for date and location call Joan at 716-889-9516.

OHIO

Solar electric classes taught at a rural solar and wind powered home with utility backup. Maximum of 12 students. Must advance register. $30 fee per person and lunch is provided. Class will be full of technical info, system sizing, NEC compliance, etc. Students will build a system. Dates: June 18, July 23, August 20, September 17. All classes held from 10 am to 2 pm on Saturday. Call 419-368-4252 or write Solar Creations, 2189 SR 511 S, Perryville, OH 44864-9537.

OREGON

IN-POWER 94: Oregon's Conservation, Renewable Energy and Solar Technology Fair. July 23, 1994 at Westmoreland Park, SE McLoughlin Blvd, Portland, Oregon 10 AM – 6 PM. Contact: The Oregon Conservancy at 503-232-3575 or 503-637-6130, Fax 503-637-3549 or write 19140 SE Bakers Ferry Rd, Boring, Oregon 97009

Oregon SunWorks '94 is underway. The dates are August 20–21. We encourage suggestions as to what should be included or dropped from the whole conference agenda. If you know a business that would like to increase it's product/service awareness in the renewable energy arena contact SEA at 503-224-7867

RHODE ISLAND

The Sustainable Transportation and Solar and Electric Vehicle (S/EV94), October 3–5, 1994, will be held at the Rhode Island Convention Center in Providence. The show provides transportation planners, auto, bus and train industry personnel, business people, fleet owners and operators, students and concerned citizens a forum to exchange information on EV technology, policy, and business, as well as transportation planning strategies to create a non-polluting, equitable and efficient multi-model transportation system. For more info contact: NESEA, 413-774-6051.

VERMONT

"Photovoltaic Home Electric Systems: Seminar and Workshop" is a one day program, held at Sunnyside Solar in Guilford. The 1994 dates are July 30, and Sept 24. Each program runs from 9 am to 4:30 pm with lunch included. This introduction to independent solar electric systems includes the hands-on assembly of a four module system. The fee is $135 with a companion registration available for $95. A $45 advance deposit is required, balance due the day of the seminar. Each session is limited to the first ten deposits. Included in the fee is a full packet of information & related articles, Joel Davidson's *The New Solar Electric Home* and Steven Strong's *The Solar Electric House.* Sunnyside Solar offers this seminar and workshop to those interested in photovoltaic and its use, particularly in residential application. For information & registration contact, Carol Levin, Sunnyside Solar, RD4 Box 808, Brattleboro, VT 05301.

WASHINGTON

The Think Green! Community & Garden Fair will be held June 26th from 10 am to 6 pm in the Seattle area. The event will have workshops, vendors, and displays focusing on water conservation, healthy home products, recycling, energy efficiency, and associated topics. For more info call PNA at 206-783-2244.

Rides Publishing Company is offering two day seminars for marine electrical installers at various dates in 1994. The seminars are intended to solve the #1 problem with boat electric today... lack of accurate knowledge about batteries, alternators, chargers, inverters, regulators and instrumentation. In depth and general information about electrical systems will be presented. Seminars will be held at selected cities. Participants will learn from David Smead, principle author of *Living on 12 Volts with Ample Power* and *Wiring 12 Volts with Ample Power* and engineer for Ample Power Products. To learn more about the training seminars, locations, and dates, and costs contact Rides Publishing Company at 206-789-5758, Fax 206-789-9003

WISCONSIN

The fifth annual Midwest Renewable Energy Fair will be held June 17–19, 1994 at the Portage County Fairgrounds, in Amherst, Wisconsin. Contact Midwest Renewable Energy Assn, POB 249, Amherst, WI 54406 • 715-824-5166

Model Home Electrical Systems Workshop. Help install the PV and wind system that powers the Model Home at the Midwest Renewable Energy Fair. Instructors are Jim Kerbal of Photovoltaic Systems Co. and Chris LaForge of Great Northern Solar. Course length: June 9–19 Cost: $100 (payable to Midwest Renewable Energy Association). Class size limited to 12, so sign up early. For more information call Jim Kerbal at 715-824-2069.

the Wizard speaks…

Brain Waves

The human brain produces a considerable amount of electromagnetic radiation. This is a low frequency, low intensity radiation in the range of two to around one hundred cycles per second (cps). These brain waves are usually classified into four groups.

Types

The first group, beta waves, are about 12 cps and above. These are the waves associated with conscious and directed attention. Alpha waves are between 7 and 12 cps and relate to a relaxed, non-directed, but still conscious state. The third type, theta waves, are between 3 and 7 cps. Theta waves are produced by states of deep meditation or contemplation. The fourth group are the higher amplitude delta waves which appear during deep sleep. These have a frequency of about 2 cps. There is a fifth type associated with dreams and the phenomena of rapid eye movement.

Causes

There is a new theory relating to the source of brain waves. It is based on Chaos Theory. This theory states that brain waves of all types and frequencies are sourced by sets of strange chaos attractors. This means that they are the sum total of groups of resonators. Each resonator is frequency modulated about a different strange attractor frequency. These strange attractor frequencies were probably first programmed by hereditary and environmental factors. Some of these factors are the same for all people, while others could be quite different.

Effects

The states of the individual strange chaos resonators and the nature of their associated brain waves seems to have an effect on other processes. These include the rates of beta-endorphin and neurotransmitter creation as well as general neuronal and nervous system response. They may also play a part in emotional and psychological consciousness.

Control

The control of brain waves may enable us to take an active roll in our own health and evolutionary development. Other effects such as enhanced intelligence and various types of extra-sensory perception and powers are possible. The technology for attaining this control partially exists today and should develop further in the near future.

¡Win! ¡Win!

Home Power's 3rd Annual

Solar Cooker Contest

1st Prize: a Solarex MSX-60 PV Module

2nd Prize: a Solarex MSX-10 Lite PV Module

3rd Prize: a Solarex MSX-5 Lite PV Module

You can win a prize! It's simple.

Our planet needs solar cookers that fit all cultures and climates, that are easy and cheap to build, and fun to use.
So go to your backyard or attic or local dumpster. See that hatbox or old Weber barbeque, that piece of window that was replaced, that left-over aluminum flashing. And start designing!

For complete rules, see HP#39 pg. 82.
For inspiration and judging criteria, see last year's contest, HP#37, pg. 22.

The Rules

1. Build a solar cooker from any materials, but simple, inexpensive, common, or recycled materials score high.
2. Your solar cooker must cook — it must reach at least 212°F.
3. The actual cooker must be sent to Home Power by 15 July 1994 or brought to the cookoff (let us know you're coming).

Solar cookoff and potluck will be held 6 August 1994 at Camp Creek Recreation Area, near Hornbrook, California. All are invited!

Send cookers to: Home Power, 19101 Camp Creek Rd., Hornbrook, CA 96044

Questions?

Call 916-475-3179

Letters to Home Power

Utilities & Who Owns The Sun

I have designed and built generators and control systems since 1976 and have been a project engineer for many large power systems. I must confess that I came late to PV technology and have been amused by the discussions, arguments and distrust between utilities and the PV industry (and consumers). Distrust of the utilities may be well-founded considering the utilities' track records — Three Mile Island, nuclear power cost over-runs, the failure of many of the PV power plants such as Carrizo Plains, Sky Harbor, and other not-so-publicized incidents. Locally we have heard of mismanagement and problems in our local San Miguel and DMEA cooperatives.

The utilities just can't seem to get together on a clear, concise energy policy and the bottom line is *all* of us now realize that for many decades now, the real cost of our energy has been hidden in out of the way places. In contaminated nuclear dumping grounds and in hundreds of coke piles removed from coal fired boilers in hundreds of power plants across America. Most of us do not realize (or want to know) what it really takes to produce the amount of energy we consume in one day. PV system owners realize this the first day they start up the expensive equipment that their hard earned money purchased. That is why they speak up first. The utilities have one major fault — they view everything on the same scale — *bigger* is better. Save 10 watts here — waste 50 watts there. Why? Because that has been our mandate to them — cheap energy at any cost!

PV offers the only real solution for the next half century: clean reliable *free* energy from the only source no one owns — the *sun.* The utilities and other agencies have ignored PV so long now it has gone beyond their comprehension and become a grass roots movement where hundreds of kilowatts are installed by private owners each year.The day will come soon when a large majority of Americans are self-sufficient energy producers. The utilities will either try to block this day from happening in true bureaucratic fashion, or try to get on the bandwagon and capture market share in the typical heavy-handed fashion with which they have approached all other ventures. I hope they can find an honest way to work with existing PV dealers and suppliers in a cooperative spirit. We certainly are willing and able to help. I kind of like the dinosaur analogy...they were big and slow — they were here and then they were gone — it may be so for our electrical monopolies. William von Brethorst, Johnson Electric, PO Box 673, Montrose, CO 81401

Glow Bar Study

I just got off the phone with you folks regarding my search for a gas range that doesn't rely on a glow bar to light the oven. I was just about to go buy one and deal with whatever it took to make it work sensibly. I'm quite excited now about the lead you gave me in Illinois. I really wasn't looking for a project. Thank you.

I found a news brief in *Environmental Building News* about a study at Lawrence Berkeley Laboratory that claims that they found that a gas oven with a glow bar consumes more electricity than a microwave to bake a potato. The glow bar ignitor studied draws 350 to 400 watts during start-up and continues to draw power during oven operation. To bake a moderately sized potato LBL reacher Brian Pon found that a gas oven started cold used 200 watt-hours, a preheated gas oven used 140 watt-hours and a microwave used 110 watt-hours. (From *Home Energy Magazine*, November/December 1993). Phew!

We live 1/2 mile off the grid, even though we are a stone's throw from the Duluth city limits. The power company wanted just enough to run lines in for me to say no and set up our own system. We have around 1,000 Watts of used TriLam PV panels and a 1,000 Watt Whisper wind generator charging a 2,200 Amp-hour battery bank. We are running a fairly normal looking house that is wired to code through an 1800 watt Heart inverter and have a fairly extensive 12 Volt wiring system alongside. About half of our lighting is DC and more would be if I could find better equipment. We just bought a Sun Frost refrigerator to replace the chest freezer I converted with a Nova Kool kit three years ago and are loving it. We have a 760 foot deep well that luckily decided to be artesian, so we are using a standard 1/2 hp submersible pump set at 160 feet that is running fine on the Heart. We make more power than we need with our PV arrays except for the dark period here from November through January. We just added the Whisper wind generator and so far, even on a cloudy day, the PV end makes it look look like a toy. We are on a bluff overlooking Lake Superior and get some amazing winds. I am not done playing with it yet and we all need toys! Thanks again for your help. Michael LeBeau, Northern Shelters, 5069 Lakewood Rd, Duluth, MN 55804

Hi, Michael. Thanks for the info on glow bar stove ignition. If you're looking for a high quality DC fluorescent lamp, then check out the TekTron reviewed on page 82 of this issue. Richard Perez

More Ranges Without Glow Bars

Thank you Therese Peffer for the heads-up on oven glow bars (*HP*#31, pg. 85), also Renee (*HP*#35, pg. 107), and Brian (*HP*#37, pg. 115), for sharing their experiences with kitchen ranges. Knowing what to look out for really helped our search for a range. Kathleen and I found another manufacturer that does not use glow bars and thought we'd pass the info along.

The Wolf Range Co. has home versions of their commercial equipment rated at 1 amp, 115 volts. Their ovens use a piezo ignited pilot to light the burner and uses 0.5 amps while the thermostat is on and no current when the thermostat is off. Ours is not a phantom load — a clock is not even an option!

Wolf's are pricey, but built! They are available in natural gas or LPG with four or six burners, combination broiler-grill and a griddle.

We waited until ours arrived so we could check it out before recommending Wolf. We did have a problem with the piezo electrons leaking to ground due to a part supplier changing to thinner insulation on the leads (Wolf is changing suppliers), but with Wolf's service manager, Brad Gilbertson's help, all is well. The burners, griddle, and oven (we did not get the broiler grill) do their job really well. We both love it.

Wolf Range Co., 19600 S. Alameda St., Compton, CA 90221-6291 • 800-366-9653. Thanks for all the good info, Paul Sears, NH6LH, PO Box 91, Naalehu, HI 96772

Hi, Paul. We use a Wolf here at Home Power Central. I agree, Wolf's are industrial quality hardware. I like the 17,000 BTU surface burners — no waiting for coffee water in the morning. — Richard Perez

And more electric ignition stoves…

I just want to tell you about a propane gas stove with no glow bar in the oven. I bought it in Canada eight years ago. It is made by Brown Stove Works Inc., PO Box 2490, Cleveland, TN 37311.

For eight years I have used the stove light to turn on the inverter, used the electronic ignition to light the gas on the top burners or in the oven, and then turned the light off after the gas is burning to put the inverter back into standby mode. The electronic ignition did not use enough electricity to turn the inverter on by just turning on the gas knobs on the stove. The stove has worked fine. I like your magazine and have every copy except #1. Would like to see more about hydro power and building your own. M. Malaowicz, Nova Scotia, Canada

A Low Draw Washing Machine

I just bought a Whirlpool model LA5243XYWI, 24 inch washing machine that uses only 3.6 amps. It uses a 114-00 direct drive motor. The washing machine is made in Mexico. I works well and runs just fine on my Trace 2012. Greg Walker, Rt1 Box 1509 C Sugar Camp Rd, Manchester, TN 37355

Thanks M. Malaowicz and Greg Walker for sharing your efficiency tips! After all, a watt saved is $6 earned (dollar per watt of photovoltaic modules). Readers, we're interested in how you conserve, so drop us a line (or FAX) and let us all in on your secrets. — Therese Peffer

Tubular Answer

This is in regards to the question about water storage tubes in the Letters section of the last issue (*HP*#40, pg. 121). Plastic water storage tubes are available from Solar Components Corp., 121 Valley St, Manchester, NH 03103 • 603-668-8186. Their catalog is $2 (unless it's gone up since 1992) and also contains lots of stuff for greenhouses — glazings, hardware, pumps, gadgets, etc. The storage tubes are expensive (for example, an five foot tall, twelve inch diameter tube costs $89.95, 1992 price), but for such places as the interior of a house where looks are important, they could be worth it. The floor joists must be able to support the weight of the water; the tubes themselves are very light. In greenhouses, where looks aren't such an important consideration, metal drums would be a better choice. Metal is faster than plastic or fiberglass at transferring the sun's heat to the water and it also radiates heat faster, hence it is more efficient. Hope this helps. Love your magazine. Betsy Bartel, 21 Happy Hunting Dr, Bellvue, CO 80512

To Share or Not to Share

I need advice concerning the complete virtues of RE power in rural America and would like to get some thoughts from you. Perhaps you can lead me to information that would help me educate myself, my neighbors, and my rural electric company.

I live near the end of a rural county road, the last three miles of which are without grid power. About three households have good efficient solar systems; about two households have marginal solar systems; and the rest of the households — about ten — are using generators for their power supply. A few residents wish to get the rural electric company to put a line up the last three miles of the road. We have been quoted a sum of $20,000/mile for that line. On top of that charge are the feeder lines to each house, also at that same line price. Thus, those living further from the road will pay more.

Ignoring human nature for a moment, let's assume that all fifteen households decide to share the cost of the three mile line. This results in a minimum price of $4,000 per household ($60,000 divided by fifteen) plus the feeder line, transformers, and all the other stuff. The local rural electric cooperative assures us that each household will get a $2,400 refund once the line is installed. Average utility rates are five cents/kW-h; estimates on yearly power bills typically fall in around $800/year.

Personally, I would prefer alternative energy systems but need some hard facts to talk to my neighbors in this situation. Is anyone available to put together a cost benefit analysis comparing solar systems to the power companies? Is any RE wizard out there interested in working up an analysis of cost for alternative energy for fifteen households to put beside the power company's (reluctant) bid to compare x number of resources used for x number of $$ used giving you x number of kilowatts? When confronted with the grid prices, many rural folks see them as cheaper, hassle-free power. In my household, we like to use the minimum amount of power to see with (all lights are compact fluorescents etc.) and work; many of these folks just wish to turn on their TV, freezers, and power tools and not have to think about what is going on.

In terms of global resources, is it actually more efficient and environmentally sound for each and every household to set up a separate system? Here we need to consider the energy and resources used, and the wastes produced to manufacture panels, batteries, inverters, backup generators, and/or wind machines etc for fifteen households. This needs to be compared to the resources used and wastes produced from having a central processing plant and running lines to all households. We also need to consider the environmental cost of replacing batteries and disposing of them throughout the life of that system. In rural America, recycling options are limited or non-existent. On the other hand, one has to consider the environmental consequences of grid power production, but is this factor even quantifiable in this particular case? In essence, I'd like to see a detailed financial and environmental analysis of fifteen separate systems compared to the same analysis of centralized power from the grid.

There is an enormous need to supply easily accessible information and applications to people who can't or don't want to do it themselves.

If alternate energy sources are not made accessible and easy for people who are fully committed elsewhere or simply aren't tech-minded, the greater use of RE will never be a reality. There are also many people that want RE systems but are not inclined to do it themselves, as we did. In rural areas, it might be better if the big power companies do get into installing RE systems. The private installers are few and very far between and it is hard for those non-self starters to get someone to help if they do want an RE system. I was particularly interested to read in HP#39, the article by the IPPP .I agree with everything they stated, but I wish to emphasize that your market is rural America! We live in a county that is actually designated "frontier" by the state. There is no grid power in a lot of this area, but people still want power. If you can get the information out to places like this, you have a ready-made, wide open market.

Is there any way, or any interest, to politically set up a grid free zone and get grants for it? I am appealing to the politicians and planners on this one. They should take time to study the possibility of setting up grid free zones in rural places that are still pristine. As well, low interest loans should be released to households to set up their own systems, not just given to the rural electric companies so they can punch in more lines. The IPPP article also raised this point that off-grid industry must be legitimized in the eyes of financial lending institutions.

My husband and I set up our solar system three years ago and live with it joyfully. We ourselves are just dabblers in the RE world and we don't have the time to educate, purchase, set up, and help maintain other people's systems. We are far removed from any solar installer. It is interesting to note that this recent push to get the power line in came from the household that has a marginal RE system. This suggests that there is a paucity of accessible information and applications available to people with good intentions. It is non-productive to preach, as a lot of RE users seem to, from a perceived "high moral ground" about the use of RE power. That is why I think it is important to generate an accurate detailed analysis of RE systems as described above to help people make decisions. I am appealing to you RE professionals to help, because I don't have the know-how or time to do it.

So, are there any altruists willing to help me and/or show me the errors in my assumptions? For anyone in the IPPP group, this could prove to be a great test case if you wish to take it on. Skylar Rickabaugh, PO Box 421, Mt Vernon, OR 97865

Skylar, You bring up interesting issues — there are others too, which come with bringing in a power line. Extending the grid would, for example, increase property taxes, and make further housing development more attractive to developers. These are elements which cannot be easily figured into a cost/benefit analysis. Back in HP*#27 we ran an article by a community in Colorado in a similar situation to your own. Contact Kris Holstrom PO Box 895, Telluride, CO 81435 • 303-728-3401.*

If any households are within a couple hundred feet of each other it may be cheapest to set up a single RE system to service them, and then keep track of who uses how much power. See HP*#24, page 14 for a system which powers four large homes at the Ananda community in the Sierra Nevada. If you know your power needs, you could get a thumbnail sketch of your costs by extrapolating from the Ananda system's cost published in the article. In terms of cost and global resources, as long as the houses are not too far away, it is most efficient for houses to share one larger system rather than have small individual systems. Bigger wind turbines, shared generators, power processing equipment, batteries, and improved chance of a good solar site for panels make shared big systems use fewer resources per household. In the largest picture, the photovoltaics on rooftops across the world, feeding the grid, could be the most environmentally sound way to meet our future electrical needs (I hope more modest than today).*

For a more accurate cost comparison, you or your local RE dealer would have to figure out the specific equipment for a system(s) that would meet your community's needs. Then compare that to the figure that the power company arrived at, including monthly utility bills. — Chris Greacen

Hi, Skylar. The cost effectiveness of an RE system depends on many factors. For example, you say an average power bill is about $800 yearly. If power costs 5¢ per kW-h, then the average home consumes 43.8 kW-h daily. Servicing a load of this magnitude is going to be expensive. Most RE homesteads use between 2 and 10 kW-h daily. We're not doing without, merely carefully using the most efficient appliances we can find. If the fifteen homes in your neighborhood were to go on a ruthless efficiency campaign, then the cost figures change radically. In terms of distance, an RE system for an efficient homestead is cheaper than 1/2 mile of newly installed utility power line. See the cost analysis of Bob-O and Kathleen's system on page 14 for a look at a particular system. In terms of cost comparison between an RE system and using an engine/generator, there is no contest. Generator operation is over three times more expensive per kW-h than using RE, and doesn't even consider the maintenance, noise, and pollution that go along with generators. — Richard Perez

PV Home Loans

We are still working on getting a loan to build our passive solar home that will be PV powered. There is good news and bad news on getting a take out loan. We have located private money for a construction loan. Fannie Mae now OKs off-the-gird houses (the good news). However, to get a loan you need several comparable sales of such houses in your area within six months. If you're the first guy to build such a house, you're out of luck. Catch-22. If anyone has any good leads or advice on getting a take out loan I'd like to hear from them. Credit or qualifying is not a problem for us — we qualify for almost twice what we want to borrow.

The home we plan to build is a passive solar envelope home kit made by Enertia Building Services. The design is so unique and successful it is patented. I think you could do an interesting article on these energy producing homes. Paul & Jeri Dostie, PO Box 1355, Mammoth Lakes, CA 93546

I recently heard that Keith Rutledge, Bank of Willits, CA • 707-459-5533, has provided at least 100 loans for RE

homes. Also the the REA is now providing loans for offgrid applications, within REA service areas (re: Federal Register Part VIII, Department of Agriculture, 7 CFR Part 1710; Volume 59, #2, January 4, 1994, Rules and Regulations). Linda Santucci (503-282-4588) is the Oregon and California REA representative. — Karen Perez

Sun Frosts in Humid Climates

Regarding energy consumption of my Sun Frost RF-16, 24 VDC, three years old.

Testing was done at latitude 24° 42" N in the Florida Keys. An SPM2000 Power Monitor was used to accumulate Watt-hours during testing and accuracy was checked with a Fluke 87. Temperature readings were taken with a humidity indicator card. The refrigerator was defrosted at the beginning of each month. The testing was done last year for three months, June, July, and August 1993.

The average ambient air temperature was in the high 80s; the average humidity was in the low 80s. Two people were using the refrigerator. The refrigerator temperature was 39°F at the bottom rear. The freezer temperature was 8°F at the rear of the freezer. The consumption in June was 1544 Watt-hours per day; in July, 1684 Watt-hours per day and in August, 1584 Watt-hours per day.

For cosmetic reasons, part of the Frig has only 4 1/2 inches of clearance above the unit. To compensate, I have vent holes to the outside at the top of the frig and vent holes through the floor in the back (house is elevated eleven feet for good air flow underneath). In addition, I have a three inch DC muffin fan running continuously in the summer creating an air flow across the condenser. The fan consumes 75 Watt-hours per day.

The frig must be defrosted at least once a month in the summer. The bottoms of the glass shelves are dripping with water and if you're not careful, things like lettuce and asparagus rot quickly.

I don't think our usage is excessive for this part of the world, but compared to up north I'm sure we make more ice and keep more beverages refrigerated and in general are putting a heavy load on it.

The main advantage of the Sun Frost is that it comes in a DC version, which compliments an RE system with DC water pumping and a few DC lights. If the inverter quits working you can live without it for awhile...other than that, there isn't any. If I lived on grid power, I'd buy the Amana TZ21R2 listed in *Consumer Reports* and with the money I saved, buy a solar hot water collector which would more than offset the controversial energy efficiency difference.

One final note on refrigerators in general: up until a few years ago, most refrigerators were energy hogs but the government has been slowly nudging them to increase the efficiency. We're finally starting to see the difference. Hallett Douville, 11 No Name Dr, Big Pine Key, FL 33043

Howdy, Hallett, thanks for the input. Your RF-16 is consuming more power than it should. I talked with Larry Schlussler of Sun Frost and he says that the humidity should not affect your RF-16's efficiency so radically. From your description, you are doing the required maintenance (defrosting, and cleaning the condenser). I am at a loss to explain your RF-16's large appetite (about 30% greater than the RF-19 we use on Agate Flat). Any suggestions, readers? — Richard Perez

Reflected Illumination

Congratulations on your excellent and always improving magazine. I'm sure that like a significant number of your subscribers, I live in an apartment with power supplied by our utility grid. Perhaps you would consider publishing more articles on energy conservation techniques for your grid-locked subscribers. I am extremely impressed with my utility, largely because they have made an honest attempt to deal with the demand reduction side of the supply-demand problem they face. Even as an apartment dweller they have provided *free* reduced flow faucet heads, shower head, hot water tank insulation, and rebates for energy efficient lights. I am typing this letter while using a 15 watt fluorescent light on a typical overcast and rainy day in the Northwest. This and the article in *HP*#39, "Solar Cooking Basics" by Alan Nichols prompted me to write you about reflectors.

I was dissatisfied with the amount of illumination I was getting from this light and decided that the reflector was not doing enough reflecting. It was a metal reflector that had been painted a soft white. I went down to our local hobby shop and purchased a sheet of reflective Mylar with an adhesive backing. It looks like a poor mirror roughly 5 by 36 inches and cost $2.36. I put it on the metal reflector and removed bubbles with a hair dryer. It appears to significantly improve the amount of light on the desk but I do not have a light meter to obtain before and after performance data. I tried the same trick on a 75 watt Mercury Vapor light for a driveway. The metal area above the bulb was covered and part of the plastic reflector to direct light away from the building. Again, it seems to significantly increase the amount of useful light and has not shown any deterioration from heat or the elements.

Since reflectors are important components of lighting, solar cooking, photovoltaic modules and other applications, I was wondering if you would be interested in evaluating the technique and reporting the results in *Home Power Magazine*? Thanks for your consideration. Charles L. Smith, 1450 Birchwood Ave #106, Bellingham, WA 98225

Hi Charles. We're always interested in reader input! You've brought up a great point. For the same amount of light, you can use a bare 100 watt light bulb or 15 watt light in a fixture that reflects and focuses that light where you need it. What a difference in energy use for the same job! We like the Osram compact fluorescent lights with the built in reflector. When my mom complained about the dim DC light in the trailer, I removed the frosted white cover, and attached an aluminum foil covered cardboard reflector. Got that light off the ceiling and down at the table where needed. It won't make the fashion magazines, but Mom was able to read without straining her eyes. Let's use that energy more efficiently! — Therese Peffer

Solar Kids

Mr. Scott's third grade class at Bear Creek School has finished doing a project. It was called Project Sun. We learned not only does making a solar oven take time but also that it takes thinking. Also, you have to know what you are doing to it and make it absorb the heat and keep it in. Our

follow up project was a solar oven that they might use in a different country. Stephanie Lange, Bear Creek School, 51 SE 13th, Bend, OR 97701

Solar Cooking Input Wanted

I want to thank those of you who have read and helped me get out my book *Heaven's Flame, A Guide to Solar Cookers*. The promotion of solar cooking is essentially a grassroots movement. Solar cookers are simple tools. But it takes more than writing about cookers to get this information out to those people who really need this survival celebration tool. Getting more folks cooking with solar takes effort learning how to use cookers and sharing this knowledge, person to person.

I am now collecting new information about solar cookers and their promotion worldwide for the next edition of my book. I welcome any comments or constructive criticism of *Heaven's Flame*. I'm trying to create a book that is not only enlightening and inspirational, but one that actually translates into more solar cookers.

For those who want to build a simple cardboard solar cooker, but don't have the time to scrounge for the ideal boxes, I have a kit available. The kit includes the important cardboard, without gloss, glue or paint and a clear step-by-step plan to enable you to replicate my favorite cooker style. When you are done you'll experience what I've been trying to share and you'll see that scrounging for boxes is well worth what you'll create. Joe Radabaugh, PO Box 111, Mt. Shasta, CA 96067

Joe's Sun Star kits can be had directly from him for $22 + $6 USA shipping. Karen Perez

Solar Pal in Pittsburgh, PA?

Thank you for all the hard work you put into the magazine. I read it from cover to cover, even though there are areas beyond my understanding.

If there is anybody in the Pittsburgh area willing to get together and talk about renewable energy, Home Power, or show me their renewable power system, I would appreciate hearing from them. Charles O'Leary, 27 Oakwood Rd, Pittsburgh, PA 95205-4220

From Gutters to Foxes

Kudos and bouquets to you all, as ever. My most important suggestion: please enlarge, or at least, restore your gutter (inner margins). With your old staple binding the gutters were 1 1/8 inches. Now, with the so called perfect binding, they are reduced to barely 3/4 inch. When the magazine is folded back on itself the text disappears around the corner. Very frustrating! Secondly, when Therese Peffer finishes discussing AA nickel cadmium cells, I hope she will give equal attention to C and D cells which power my radios and flashlights. Thirdly: give us photos of staff writers: Amanda Potter is a fox as well as a women who knows her techie-gore. She vanished from the masthead of *HP*#36. Carried away by some lucky nerd? Fourth: those operate at 24 V and upwards sometimes feel neglected by you old fashioned 12 Volters. Fifthly and finally, I appreciate your conservation consciousness as the magazine rockets onwards and upwards. Keep on keepin' on writing our declaration of energy independence. Norris Eisenbrey, 5617 High Meadow Dr, Weed, CA 96094

Hi Norris, We're kind of between a rock and a hard place on the binding. Increasing the margins would decrease the amount of info we can fit on a page. Going back to saddle stitch (the staple binding) would limit the number of pages per issue. Sorry! Therese Peffer is not planning on doing anything on C and D cells. Why? This is Therese's last issue with Home Power*, WAAH!!! (It's all Captain Tofu's fault.) She's going back to school to get a degree in architecture. She will be sorely missed. We hope we'll be able to talk her into writing the occasional article for* HP*. Amanda Potter did go back to school last Fall, so she can teach others techie-gore. Lastly, the main system article in this issue is a 24 Volt system. We don't want anyone to feel neglected! — Karen Perez*

With regard to C and D cells, Norris, realize that many manufacturers set a C cell inside a D cell casing. If you notice a D cell with less than 4 Amp-hours capacity rating (I've seen 4.4 Amp-hour D cells), keep looking! I found that AA cells were most commonly used and they are so much cheaper than C and D cells. — Therese Peffer

Greenhouses

My wife and I have now settled on 124 acres in southern Vermont. For now we are living in a small addition to the existing barn which is only 250 feet from grid power so we are "hooked up". Our goal is to build a permanent home up in the field which is 3000 feet from the closest power. I have no desire to "feed" the power company and they want between $20,000 and $23,000 to run grid power. Then we have the privilege of paying them each month! So once again alternative energy is a must. I have been looking at China Diesel generators, with solar, as one option. We could go straight solar too. Considerations affecting our choice are around heavy energy usage, like welding and greenhouse ventilation. I know welding can be done with several options and at this point I am researching the possibility of natural and solar ventilation for the greenhouses. If you know of anyone using solar for all or a majority of their power for greenhouses I am very interested in contacting them. Anyway at this time we are gathering much information and doing a lot of planning. *Home Power* offers us much very "useable" info. Thanks for all the energy and time put into the magazine. Frank Calhoun, RR1 Box 662, Putney, VT 05346

Hi Frank, Chris Greacen did an article in HP*#34, page 55 on a solar greenhouse ventilation system that he installed for his mother's 15 by 20 foot greenhouse in Washington. Cost is very low for a one or two module system driving fans. Welding is easily accomplished directly on PV/battery power. See* HP*#33 with Bill Battagin's article about his solar-*

powered welding shop. If you are considering using an engine/generator, then design the system so that the generator only runs less than 200 hours yearly. I'd recommend a Honda generator, it will last. — Richard Perez

Internet FYI

The Photovoltaic Design Assistance Center at Sandia National Laboratories in Albuquerque, NM is available to answer technical requests on problems as well as industry information on the following topics in renewable energy: photovoltaic power systems, photovoltaic augmented systems (where the energy source is primarily something else, such as diesel fuel), small wind power, solar thermal.

All interested persons need to do to avail themselves of this resource is to formulate an email message to the PVDAC manager, Jeff Zirzow. Send your message to the following address: v+sandia@p1.vita.permanet.org

The message should state clearly the kind of problem you are having and/or the type of information you wish to receive. (The message will be sent via low earth orbit satellite to the Sandia satellite station. There is presently no other Internet email service available to the PVDAC.)

They look forward to being of service, especially to interested parties in Asia, Africa and Latin America. Rex A. Martin, Nebraska Technical Assistance Center, University of Nebraska Lincoln

An RV PV Ham

I would like to hear from other solar powered RV Hams. I am an RV radio amateur (ham). Solar power is made to order for radio equipment. I use two Siemens panels on the roof, one M-16 Bobier controller, and two Trojan 12 Volt deep cycle batteries. My batteries are fully charged by noon, on the road. We use a 12 Volt TV, 12 V radio for broadcast reception, an ICOM FRG-7, and some 12 V lighting. It's a pleasure to use solar instead of running a generator, no noise, no fuss, no bother. The panels are working all the time. 73s. W6IWD, Art B, 8390 Santa Ynez Ave, Atascadero, CA 93422

Hello Art. The Home Power crew is mostly Hams, and I know there are more out there. Solar is made to order for RVers too. I heard from a guy recently who had been replacing his batteries frequently in his RV until he bought some solar electric modules to keep them charged. He figures the modules pay for themselves in battery replacement costs! — Therese Peffer, KB7WRP

It's Contagious

I paid my last power bill in 1972. The last 22 years have been pure pleasure. I live close to the land but very comfortably. I meet my own needs for power, water, and some of my food without breaking into a sweat. Part of the ease of doing this, in recent years, has been having *Home Power Magazine* available. This sort of thing is contagious, because now there are five homes in our canyon using photovoltaics. None are connected to the grid. Sometimes when people come to visit they just stand and watch the wind generator turn in my yard, and say, "That's beautiful." I have a little sign posted over my refrigerator saying, "The hotter the sun, the colder the beer." I know that we could break our dependence on petroleum products for transportation too, if we were motivated. Personal electric vehicles, bicycles, availability of fuel cells...lots of ways to go. I rode a bicycle from Vancouver, B.C. to Key West, Florida a few years ago. More of us could travel that way. Incidentally I am 65 years old.

Being gentle to the little piece of land we own...and being intelligent about the way we live in our world, seem to me to be mandates we should heed. Jerry Igo, PO Box 603, Mosier, OR 97040

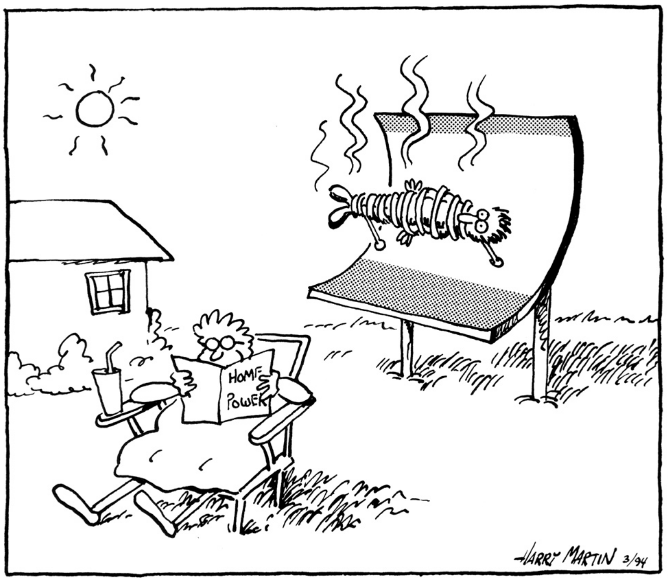
Thanks for the inspiration, Jerry! — Therese Peffer

A Foster Teacher?

The glossy cover disturbs me — I trust that you wouldn't use anything non-recyclable; (not that anyone would let go of their *Home Power* library), but I felt safer with the old ones. The new one looks so nice I didn't recognize it!.

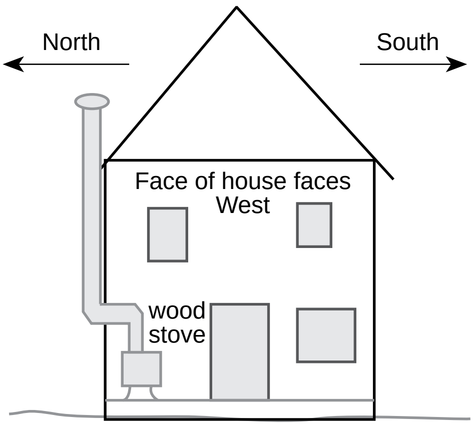
I need to read more basic bonehead renewable energy articles, either in future issues, back issues, or the library. Could you list a few references to same? Is there anyone in Sonoma County that would "foster" me? LK Smith, 455 Donna Dr, Windsor, CA 95492

Hi. Yes, the paper in HP *is both recycled and recyclable (see* HP*#34, #35 & #38 for paper nerd stuff). Right now we are looking into a totally tree-free, non-chlorine made from hemp and other plant fibers (Tree Free Paper, 503-295-6705). I was told that the company is currently working with the Sierra Club's magazine to develop a cost effective coated stock. For the basic RE info you can try Dr. Kluge's articles (*HP*#31, #32, #33, #34, & #35), or Back to the Basics articles (*HP*#32, #33, #34). Joel Davidson's book* The New Solar Electric Home *and* The Solar Electric Independent Home Book *by Fowler Solar Electric Inc. Both can be had from most RE dealers. — the Home Power Crew*



FED UP WITH HER HUSBAND'S SOLAR PROJECTS, THELMA STARTS A PROJECT OF HER OWN.

Q&A



Smoky Pipes

We have a house in which we installed a stove with a tall pipe assembly. The stove is placed near a north wall on the main floor. The stove pipe rises out of the stove, angles 90° out of the wall, turns 90° again back upward through the lip of the roof, and stands about 12 feet above the lip of the roof. The stove has been a great addition to the room, and has cut our heating bills in half or more.

There is a small (well, okay, very annoying) problem, however. In the Red River Valley, it is not uncommon to have north or northwest winds of 20–50 mph in the winter. These reached a record wind-chill low this year of –90°F. Only when the wind is out of the north do we have our problem. The problem is that a north wind creates a violent downward pressure on the air column in the stack. We have had full-tilt fires going in the box and had them snuffed by this downdraft. Needless to say, the "snuffing" of a good fire results in the production of copious clouds of smoke — in our house. It's a real treat to air out the house with –60° winds.

One possible clue — when the wind is out of the south, the fire rages out of damper control. Thus it seems to be the opposite of the north wind problem. When we lived on the Oregon coast, we noticed that the fire stacks there had "swivel" chimney caps. Is this to prevent a wind problem? Would these solve our problem? Any comments would be helpful. We hope to take care of the problem this summer sometime. Thanks in advance.

P.S. How does one get a password to the computer BBS and what are the charges involved. John Weiland, RR1 Box 44, Sabin, MN 56580

Hi John, fortunately (or unfortunately), I've experienced this problem myself. I have a few customers who complain about an occasional little puff of smoke into the house. Almost all of these last less than one second and happen a few times a year. Not so with your situation which generates enough smoke to prompt you to open up the house when it's so cold. This is a rare complaint.

Because I'm a woodstove nerd, I've played with this phenomena when it occurs at my shop in Genesee, California. My smoking experience has been from several seconds up to half a minute of thick, acrid smoke — no thanks! A few conclusions: all the usual elements that make for a strong draft (chimney height, lack of elbows, as much insulated chimney pipe inside the house as possible and lack of creosote), play only a minor role. I have all the right ingredients for a strong draft plus I increased the height of my chimney and used a swivel type cap. Yet, when the wind is "just right", the smoking returns. I have tried a medium hot fire to counteract the draft reversal too, with some success.

Your drawing indicates two elbows in your chimney/stovepipe and most of your chimney is outside the house (thus cooler), at least two counts against strong draft. If your chimney is the type that is "air insulated" versus "fiber insulated", it will run cooler yet.

Though I cannot technically document this conclusion, I feel confident that rather than a pressure being exerted at the chimney top we're dealing with a negative pressure in your home.That culprit wind is not just influencing the draft at the chimney's top, I think it is pulling smoke out of your stove's intake via the negative pressure in your house induced by the same wind.

During these smoking episodes I have run around the shop turning off exhaust fans (in your home, bathroom or kitchen exhaust fans), and/or opening specific (pressure side) windows. These things have helped a lot. Opening windows is not a solution, though. In the big picture, a "tight" house (eg. weather stripping, vapor barriers and caulking) will go a long way to reducing the effect of the wind's negative pressure impact on your place. I believe it's a matter of assessing the effects of your particular wind on openings, leaks, other chimneys, ducts, and foundation vents to find how it creates a negative pressure inside. Maybe a fluid mechanics engineer....Good luck, Bill Battagin, Feather River Stove Works, 5575 Genesee Rd, Taylorsville, CA 95983, 916-284-7849

To get a password on the HP BBS, all you have to do is call the BBS (707-822-8640), follow the screen prompts and make up your own password! There is no charge for using the HP BBS — Karen Perez

Shunt Regulator

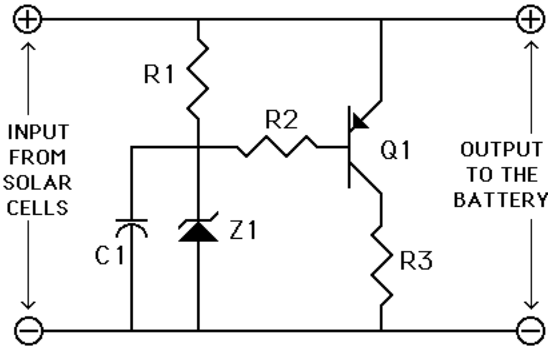
I am enclosing a reprint of an article on a charge controller. It is from a book about batteries. I don't remember which book it was but I found this xerox in my files. I am just starting out in PVs and would like to build a charge controller. This one looks very simple and the parts are readily available, no special ICs that are next to impossible to get. The car headlamp which could be used as a substitute for the 100 watt 2 Ω resistor has possibilities.

Could you comment on this controller? How much current can it handle and is it any good? Do you have plans similar to it? I realize there are more "Hi Tech" devices out there but this one looks simple and cheap to build. Any comments would be appreciated.

PVs up here in Canada are slowly gaining some acceptance but with limited winter sun it is a long hard struggle. Thanks

Figure # 6-2.

SHUNT REGULATOR FOR SOLAR CELLS



Q1- MJE 2955 or equivalent
Z1- 1N5352 or equivalent
R1- 2KΩ, 1/2 watt
R2- 50Ω, 10 watt
R3- 2Ω, 100 watt, or a 12 volt car headlight
C1- 0.1µf, 25 volts

for a great magazine! Gerrit Wiedmer, 58 Dawn Ridge Trail, Brampton, Ontario, Canada L6Z 2A2

Hi, Gerrit. Well, your letter is a surprise. That schematic came from The Complete Battery Book *which I wrote in 1985. Yep, the regulator is ultra simple and it works fine if you stay within its limits. Maximum current is limited by R3 to about seven amperes, making this a good two module regulator. The 1N5352 is a 15 VDC, 5 Watt, zener diode, hence the regulator functions at about 16 VDC. If you use a 14 Volt zener (1N5351), then the regulator operates at about 15 VDC. Be sure to heatsink the MJE 2955, as it will get hot. — Richard Perez*

Lasers, Nickel Iron Batteries & BBSs

We have a couple of questions. First, Real Goods indicates in their Sourcebook that they do not recommend the use of laser printers with power inverters. It seems that the protective circuits in the printers are upset by the quality of even the best inverters. Since you indicate that you use laser printers in the production of the magazine, could you give us information on the brands of printers and inverters you use and maybe some indications on how this is actually working out? We are intending to run our entire household on 12 Volt power (including lap top computers) but would like to have a laser printer (and possibly a copier) on inverted power if we can't find 12 Volt versions of them.

Our second question is regarding nickel iron batteries. We have acquired a set of old Edison cells. They are charging reasonably well off our single Kyocera panel, but we want to make sure they are operating under optimum conditions and maintain them for the longest possible life. In issue #34 Richard Perez wrote an article on alkaline battery operating tips. He indicated that he would be writing about reconditioning this type of battery in the next issue, but no additional article was published. Has he ever put this information together and if so can we get a copy somehow? We only paid $100 for the set of 10 cells and we're willing to spend some time and money to make them right. They are Edison A4H cells and are running about 1.35 volts and just under 8 Amps per cell. A couple cells were low on fluid when we got them (they had been sitting in storage for many years). We filled them with distilled water and topped all cells with mineral oil before we started charging.

We have been subscribers for years and appreciate the quality of the information you provide. We've also enjoyed the process of change and growth that the magazine has gone through. We look forward to making use of the BBS, although the long distance charges involved are a little disconcerting. Do you take part in any of the alternative energy groups on the Internet or any other on-line services? Pat Therrien, David Sower, Rt1 Box 504, Riner, VA 24149

Hi, Pat. Laser printers (and copiers using laser diodes) will run on sine wave inverters like those made by Exeltech, Dynamote, and Trace. These devices use thyristors (triacs) to control the power delivered to the lasers. Thyristors will not function with modified sine wave inverters. They will work just like downtown on sine wave inverters. We use both Exeltech and Dynamote sine wave inverters to drive Home Power computer systems (including a Hewlett-Packard 4M laser printer). No problems and no power outages or spikes. I'm working on the alkaline cell reconditioning information. We still need a disposal source for spent electrolyte. Reconditioning is a last ditch effort. Before considering reconditioning, check all cells for capacity. It sounds like yours are functioning, so make sure that you actually need to recondition them. I currently check into the HP BBS when our radiotelephone is clear and noise free. We are relocating the R/T's base end to improve transmission quality. When this is finished, then I hope I'll be able to more reliably access computer services. — Richard Perez

An Answer for J Mark's question about microhydro efficiency in *HP*#39, page 107

I manufacture the Stream Engine referred to in HP*. I also make a machine with a PM DC motor. It could produce slightly more power at Bob-O's site but its maximum output is about 3 Amps. Of course larger PM motors are available, but they all share the same faults. Because all the output power is carried by the brushes, and they must contact the segmented commutator bars, there will always be a maintenance headache there.*

At the site in question the machine is operating at the very bottom end of its operating range so most of the input energy goes to overcoming parasite losses (bearing and brush friction, windage)

I am presently working on some new designs of PM rotor alternators. I have made these since 1986 or so, but I hope the next generation will solve some of the problems like lack of a control function.

So it isn't a low efficiency over the whole range we are dealing with. A better site's overall efficiencies of 50% are readily achieved and that figure is always being pushed higher. Paul Cunningham, Energy Systems and Design,PO Box 1557, Sussex, NB, Canada E0E 1P0

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